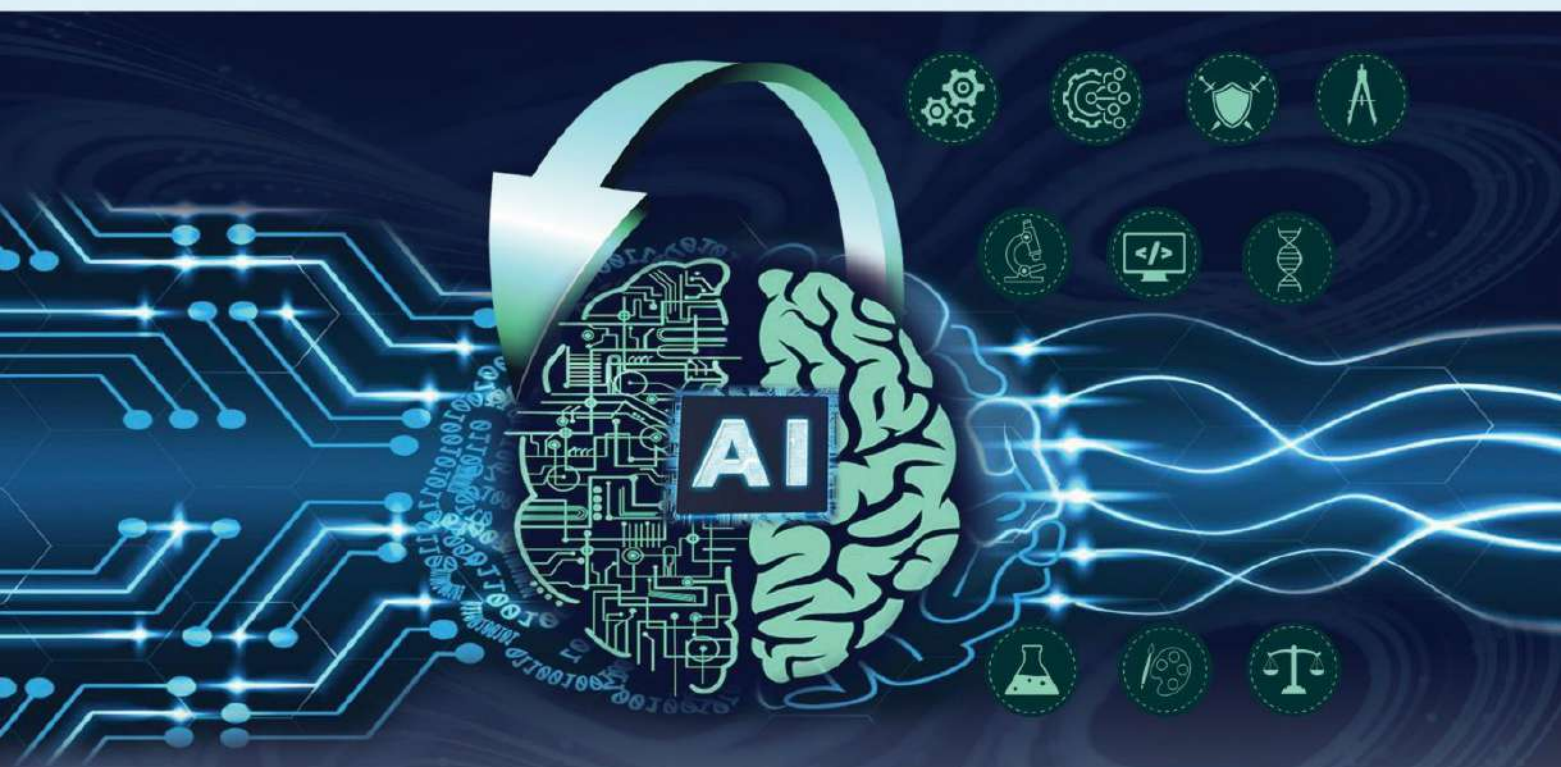




17th INTERNATIONAL RESEARCH CONFERENCE

*"Unravelling the Paradigm Shift:
Revolutions in the Era of AI"*

26TH - 27TH SEPTEMBER 2024



MANAGEMENT, SOCIAL SCIENCES AND HUMANITIES

PROCEEDINGS



17th INTERNATIONAL RESEARCH CONFERENCE

UNRAVELLING THE PARADIGM SHIFT: REVOLUTIONS IN THE ERA OF AI

MANAGEMENT, SOCIAL SCIENCES AND HUMANITIES



General Sir John Kotelawala Defence University
Ratmalana, Sri Lanka.

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Message from the Chief Guest



I am truly honoured to welcome all the distinguished participants to the 17th International Research Conference (IRC) at General Sir John Kotelawala Defence University (KDU). This annually organized conference serves as a unique milestone showcasing the rich research culture deeply embedded within KDU. As a prestigious seat of learning, novelty and innovation remain at the heart of KDU's mission. Therefore, 'Unravelling the Paradigm Shift: Revolutions in the Era of AI' has been chosen as the key theme of IRC 2024.

Moving ahead with the momentum of modern-day research, we are set to uncover the extensive impacts of artificial intelligence, not just in defence but across every facet of national interest. Currently, AI has become a driving force, reforming our defence strategies, transforming healthcare, and restructuring our educational frameworks and infrastructure.

Investing in research is essential for national advancement, promoting innovation, formulating policies, and offering solutions that address our most pressing challenges. Hence, the IRC serves as a vital platform that fosters such great endeavours, contributing significantly to national development. Our responsibility as defenders of national security is profound, extending beyond traditional roles to include the ethical integration of advanced technologies that ensure our nation's safety and prosperity.

KDU stands as a symbol of a rich and diverse research culture across many disciplines. It is also a hub for high-quality research, upholding international standards of academic excellence. This conference represents a critical meeting of minds where leading experts converge to define strategies for our future. Each discussion and presentation at this event is a step toward securing a thriving, prosperous future for our region.

I extend my best wishes to all for a successful and productive conference, eagerly anticipating the innovative ideas and transformative insights that will undoubtedly arise.

**GENERAL SHS KOTTEGODA (Retd) WWV RWP RSP
VSV USP ndc**
Chancellor General Sir John Kotelawala Defence University

Message from the Keynote Speaker



Brain health is a holistic concept encompassing cognitive, sensory, social-emotional, behavioural, and motor functions, enabling individuals to achieve their full potential. With one in three people globally affected by a brain disorder, the urgency for preventive brain health initiatives is evident. Since the inception of World Brain Day in 2014, there has been a renewed global focus on this critical area. The World Federation of Neurology (WFN), in collaboration with key organizations such as the American Academy of Neurology (AAN), the European Academy of Neurology (EAN), and the Asian Regional Consortium of Headaches (ARCH), has led the charge to raise awareness and promote brain health worldwide.

This keynote address will outline the journey of World Brain Day and its impact on the global brain health movement, with a specific focus on prevention. It will explore the evolution of brain health concepts and the alarming prevalence of brain disorders, emphasizing the need for urgent, coordinated action. Central to this effort is the role of artificial intelligence (AI) in enhancing preventive brain health strategies. AI-driven technologies are increasingly being used to predict, diagnose, and monitor brain health conditions, enabling earlier interventions and more personalized approaches to prevention.

The address will highlight the author's pioneering work in community-based programs, public health campaigns, and international collaborations. It will underscore the critical role of prevention, early intervention, and AI-powered tools in improving quality of life and reducing the global burden of brain disorders. The ultimate goal is to advance comprehensive brain health initiatives that leverage cutting-edge technologies to ensure a healthier future for all.

Professor Tissa Wijeratne

DR OAM MD PhD FRACP FRCP(London) FRCP (Edin) FAAN (USA)
FEAN (EAN) Professor and Chair, Director, Senior Neurologist,
Department of Neurology, Western Health, Victoria, Australia Co-
Founder and Co-Chair, World Brain Day, World Federation of
Neurology

Message from the Vice-Chancellor



Greetings to all participants, speakers, and guests of the 17th International Research Conference (IRC) at KDU. This year's IRC is centered around a timely theme that has sparked diverse dialogues in the realms of research and innovation. The theme, 'Unravelling the Paradigm Shift: Revolutions in the Era of AI', serves as an eye-opener for both eminent and novice researchers across the globe. It also highlights the critical role that advanced technologies play in shaping our world.

At KDU, we take pride in being at the forefront of defence education in Asia, a distinction affirmed by our high rankings and our pivotal role in shaping global security dialogues. KDU claims to have a unique history of providing high-quality education for both military and civilian students. It also proudly stands as a thriving hub for cutting-edge research that addresses pressing global and national issues. We strongly believe in fostering a rich and diverse research culture among KDU's students and staff, aligned with international standards. Therefore, IRC is recognized as a key event in KDU's annual calendar, emphasizing its significance in the institution's academic and research endeavours.

This year, we aim to explore the revolutionary impacts of AI across diverse disciplines, reaffirming our commitment to leading these discussions on a global scale. The insights shared here will undoubtedly spark new research initiatives and strategic collaborations, enhancing Sri Lanka's stature as a leader in both academic and strategic domains.

I extend my sincere gratitude to all those whose collective efforts have brought this conference to a reality. Your contributions ensure that KDU plays a prominent role in the international arena, driving discussions that will shape the future of technology and strategy. I look forward to a successful event, characterized by insightful discussions and pioneering ideas.

**REAR ADMIRAL HGU DAMMIKA KUMARA, VSV,
USP, psc, MMaritimePol, BSc (DS)**
Vice Chancellor General Sir John Kotelawala Defence University

Message from the Chairperson



It is my honour, as the Chairperson, to welcome you all to the 17th International Research Conference at KDU. This year, we explore how artificial intelligence has evolved from a technological innovation into a catalyst for transformative change across numerous sectors. With an impressive selection of 441 research papers, drawn from nearly 1000 submissions, our conference spans across 11 distinct tracks covering a wide range of disciplines. Our theme, “Unravelling the Paradigm Shift: Revolutions in the Era of AI,” highlights the profound and far-reaching transformations that AI is driving—from reshaping urban infrastructure to revolutionizing healthcare. The conference is designed to promote interdisciplinary dialogue, addressing not only technological advancements but also the ethical, social, and economic implications of these developments. One of our key objectives is to create a platform where researchers, professionals, and thought leaders can come together, exchange ideas, and foster collaborative initiatives that will push the boundaries of innovation. I am deeply grateful to all our keynote speaker and the plenary speakers, other presenters, , participants, and the entire organizing team for their tireless efforts and contributions. Your dedication to advancing knowledge is what brings this conference to life, positioning it as a critical forum in global research. Together, we are charting a path toward a future where technology and society grow hand in hand, reshaping the landscape of not just research but our daily lives. Let’s engage in meaningful discussions that will inspire new perspectives and drive impactful solutions. Here’s to a successful conference, rich in insight and collaboration. Finally, I would like to extend my best wishes to all the presenters, authors, and participants joining the KDU IRC 2024, whether on-site or online. I hope each of you finds this conference not only informative and enjoyable but also an encouraging opportunity to experience the warm hospitality of KDU throughout these two fruitful days.

Dr. Niroshta Wedasinghe

Ph.D(KDU-SL), MIT(CStud-Aus), B.Sc in Comp IS (London Met-UK), SMIEEE(US), MBSC(UK), MCS(SL), FISDS(Japan) Senior Lecturer cum Director -Centre for Gender Equity and Equality General Sir John Kotelawala Defence University Conference Chair-IRC 2024

Message from the Secretary



As we gather for the 17th International Research Conference at KDU, I extend a warm and heartfelt welcome to all participants, researchers, and thought leaders. This year, we proudly present 441 research papers selected from nearly 1,000 submissions, spanning across 11 tracks in diverse fields such as Defence and Strategic Studies, Medicine, Health Sciences, Engineering, Technology and Computing, Basic sciences, Law, Social Sciences and Humanities, and the Built Environment and Spatial Sciences. Our theme, “Unravelling the Paradigm Shift: Revolutions in the Era of AI,” reflects the profound ways that AI is transforming our world, becoming integral to our lives and work. The discussions here aim to explore how AI can address global challenges, drive innovation, and foster interdisciplinary collaborations that will shape the future. Looking ahead, the future of IRC lies in broadening its horizons. We aim to increase international participation, diversify the scope of research, and establish global research consortia to tackle real-world problems that extend beyond the borders of Sri Lanka. The insights gained here must lead to actionable outcomes, particularly in formulating policy recommendations in areas such as AI in defence, public health, and education. This conference is more than just a forum for discussion; it is a platform where the brightest minds collaborate to drive change. I extend my heartfelt thanks to all our speakers and participants for their dedication and contributions. Together, we are not only shaping the future of research but also crafting solutions that will impact society on a global scale. Here’s to a successful and inspiring conference that drives innovation, shapes policy, and sparks meaningful collaboration.

Dr. HM Prasanna Herath

Ph.D. (USJ), RN(SLNC), B.Sc(Nursing) Hons (UPSL), CTHE Senior Lecturer Faculty of Allied Health Sciences Erasmus coordinator General Sir John Kotelawala Defence University Conference Secretary- IRC 2024

Message from the Dean



I am delighted to welcome you to the 17th International Research Conference of General Sir John Kotelawala Defence University. This year's theme, "Unravelling the Paradigm Shift: Revolutions in the Area of AI," highlights the transformative impact of artificial intelligence on our world.

AI, once a futuristic concept, is now a driving force behind advancements in various fields. This conference's focus on AI underscores the importance of understanding its potential to reshape our societies, economies, and everyday lives. As academics, researchers, and practitioners, we have a critical role in using these technological advancements responsibly and ethically.

The Faculty of Management, Social Sciences, and Humanities is committed to exploring the broader implications of AI, from ethical considerations to societal impacts. We believe that interdisciplinary collaboration is essential to harness AI's benefits while addressing the challenges it presents.

I extend my heartfelt gratitude to all contributors and organizers for their efforts in making this conference a success. I encourage all participants to engage actively, share insights, and explore new ideas that will contribute to the responsible evolution of AI.

Wishing you all an inspiring and productive conference.

Dr (Mrs.) LS Liyanage

Dean, Faculty of Management, Social Sciences, & Humanities

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Leveraging Artificial Intelligence Enhance public transport efficiency in Sri Lanka

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Abstract - This study investigates the potential of Artificial Intelligence (AI) to significantly enhance the efficiency of public transport systems in Sri Lanka. As the country grapples with challenges such as traffic congestion, scheduling inefficiencies, and inadequate service coverage, the application of AI offers promising solutions to optimize operations and improve commuter experiences. The research focuses on the deployment of AI-driven technologies, including predictive analytics, real-time data processing, and the Internet of Things (IoT), to streamline bus and train schedules, reduce waiting times, and allocate resources more effectively. Through a comprehensive analysis of existing public transport data and AI implementation strategies in comparable global contexts, this study identifies key areas where AI can deliver tangible improvements. The research methodology comprises preparatory steps like creating AI models for the specific transport problems faced by Sri Lanka and then conducting simulations and pilot tests to evaluate their effectiveness. The initial findings suggest that AI can manage to save about 20% of the time for travel and make the services more reliable, thus enhancing the efficiency and usability of the public transport system. The study concludes with recommendations for policymakers and transport authorities on integrating AI into the national transport infrastructure, emphasizing the need for a phased approach that includes stakeholder engagement, capacity building, and continuous monitoring. By leveraging AI, Sri Lanka can not only enhance the operational efficiency of its public transport but also contribute to broader goals of sustainability and urban mobility. This abstract clearly outlines the research's focus, methodology, and expected outcomes, providing a concise and informative overview of the study.

Keywords: Artificial Intelligence, Public Transport, Machine Learning, Internet of Things

I. INTRODUCTION:

Public transport is vital for improving the standards of mobility, cutting down traffic congestion and protecting the environment. In Sri Lanka, the present public transport system largely depends on buses and trains and is riddled with problems like poor frequency, traffic delays, and wastage of human effort. These shortcomings reduce the travel experience for commuters and thus make public transport systems unfavorable. Though these challenges exist, the use of Artificial Intelligence (AI) technologies such as predictive analytics, real-time data processing, and IoT solutions can be employed to solve the problems and bring out operational efficiency. With the help of AI, it is likely to come up with better bus and train timetables, cut down passengers' idle time waiting for buses/trains and ensure that public translocation systems are made to work more efficiently. This study focuses on the possibilities of using AI to increase the operability of the public transport network in Sri Lanka and provides steps on how it can be done.

II. RESEARCH METHODOLOGY

In this study, a mixed-method approach is employed, looking into the potential role of AI in the public transport system in Sri Lanka. The research process combines qualitative and quantitative approaches, which involve but are not limited to, interviews with transport authorities, surveys with commuters, and analysis of secondary data from existing databases for public transport.

This particular modeling effort will focus on transport issues like scheduling inefficiencies and include the development of optimization models for resource allocation. These models will be verified via simulations, and their practical applicability will be checked in pilot projects.

III.: LITREURTE REVIEW

. Sri Lanka's public transport system faces numerous challenges, including overcrowding, unreliable

schedules, traffic congestion, and outdated fleet management practices. Studies highlight the high dependency on buses, which account for about 60% of the daily commuting needs, followed by trains and three-wheelers (autorickshaws) (Perera, 2020). Inefficiencies in the bus and train scheduling systems lead to long waiting times, causing delays and frustration among passengers (Fernando & Rathnayake, 2019). Furthermore, the lack of integration between different modes of transport exacerbates the commuter experience, underscoring the need for technological interventions.

AI-driven predictive analytics can enhance public transport efficiency by forecasting passenger demand based on historical data, weather conditions, and socio-economic factors. For instance, machine learning algorithms can analyze vast datasets to predict peak travel times, enabling transport operators to allocate resources more effectively (Shukla et al., 2021). In Sri Lanka, predictive analytics could address irregular bus schedules and overcrowded trains by dynamically adjusting service frequency to match passenger demand.

Route optimization is a critical area where AI can significantly improve public transport efficiency. AI algorithms such as genetic algorithms and reinforcement learning can identify the most efficient routes by considering real-time traffic data, road conditions, and passenger load (Nair et al., 2020). In Sri Lanka, where road congestion is a major issue, AI-powered route optimization can help buses and other public transport modes avoid traffic bottlenecks, thereby reducing travel times and operational costs.

AI-driven smart ticketing systems can streamline the ticketing process, reducing boarding times and enhancing the overall passenger experience. Technologies like Natural Language Processing (NLP) and Computer Vision can facilitate seamless payment and ticket verification processes (Kim & Kim, 2020). Implementing smart ticketing in Sri Lanka would not only improve efficiency but also provide valuable data on passenger behavior, which could be used to further optimize transport services.

Several cities worldwide have successfully implemented AI in public transport with positive outcomes. For example, Singapore's Intelligent Transport System (ITS) leverages AI for traffic management and demand prediction, significantly reducing congestion and improving public transport reliability (Goh et al., 2021). Similarly, cities in India have used AI to optimize bus schedules and reduce waiting times, demonstrating the potential for such applications in Sri Lanka.

Despite the promising potential of AI, there are challenges in implementing these technologies in Sri

Lanka. Key barriers include limited digital infrastructure, inadequate data availability, and resistance to technological adoption among transport operators (Jayasinghe & Silva, 2023). Additionally, high costs associated with AI technologies and the need for skilled personnel pose further obstacles. Addressing these challenges requires coordinated efforts between the government, private sector, and international development partners.

Leveraging AI to enhance public transport efficiency in Sri Lanka holds significant promise. By addressing challenges such as route optimization, demand forecasting, and fleet management, AI can transform the country's public transport system into a more reliable, efficient, and passenger-friendly service. Future research should focus on pilot projects to test AI applications in real-world settings, develop localized AI models tailored to Sri Lanka's unique transport dynamics, and explore partnerships to build the necessary digital infrastructure.

IV. CURRENT STATE OF PUBLIC TRANSPORT IN SRI LANKA

. Public transport in Sri Lanka is a crucial component of the country's transport infrastructure, serving millions of commuters daily. The primary modes of public transport include buses, trains, and three-wheelers (autorickshaws), with buses and trains accounting for the majority of passenger traffic. Despite its significance, the public transport system faces numerous challenges, including outdated infrastructure, inefficiencies in operations, and poor service quality, which hinder its effectiveness.

- **Modes of Public Transport**

Buses: Buses are the most widely used mode of public transport in Sri Lanka, accounting for about 60% of daily commuting needs. The bus network consists of both state-operated (Sri Lanka Transport Board, SLTB) and privately operated buses, with over 20,000 buses in operation. However, the bus system is plagued by issues such as irregular schedules, overcrowding, and poor maintenance. The lack of proper regulation and coordination between private and public operators further exacerbates these problems.

Trains: Sri Lanka Railways (SLR) operates the country's train services, providing long-distance, commuter, and suburban services. The rail network covers key routes connecting major cities and towns, with the coastal, main, and hill country lines being the most utilized. Despite the rail system's potential to reduce road congestion, it suffers from aging infrastructure, frequent breakdowns, overcrowding, and delays. The train service is often considered unreliable, with outdated locomotives and carriages needing urgent upgrades.

Three-Wheelers and Taxis: Three-wheelers, commonly known as "tuk-tuks," are popular for short-distance travel and as a last-mile connection from bus and train stations to homes and workplaces. However, they are generally unregulated, leading to safety and pricing concerns. Recently, ride-hailing services like PickMe and Uber have introduced more structured taxi services, offering a more reliable but costlier alternative.

Other Modes: The introduction of modern modes like ride-sharing bikes, electric scooters, and minibuses is still in its infancy and mainly confined to urban centers. Non-motorized modes such as cycling and walking are limited due to inadequate infrastructure and safety concerns.

- **Challenges Facing Public Transport in Sri Lanka**

Congestion and Delays: Road congestion, especially in urban areas like Colombo, significantly impacts bus and train punctuality. According to the Road Development Authority, traffic congestion leads to an estimated 40% increase in travel time during peak hours.

Aging Infrastructure: Both buses and trains suffer from outdated infrastructure. The majority of buses lack modern amenities, and many are in poor condition due to inadequate maintenance. Similarly, the railway infrastructure, including tracks, signaling systems, and rolling stock, is outdated, resulting in frequent delays and breakdowns.

Operational Inefficiencies: Inefficiencies in scheduling and route management are major issues. Buses often do not adhere to fixed timetables, leading to erratic service intervals and overcrowding during peak hours. Train schedules are frequently disrupted due to mechanical failures, track issues, and other operational challenges.

Safety Concerns: Safety is a significant concern in Sri Lanka's public transport system. Overcrowding in buses and trains increases the risk of accidents, while poorly maintained vehicles contribute to frequent breakdowns. Three-wheelers and buses are often involved in road accidents, highlighting the need for better safety regulations and enforcement.

Lack of Integration: The absence of an integrated public transport system makes commuting cumbersome. There is little coordination between different modes of transport, such as buses, trains, and taxis, making it difficult for passengers to transition smoothly between them. This lack of integration often results in longer travel times and a poor overall commuter experience.

Environmental Impact: The reliance on diesel-powered buses and aging train engines contributes significantly to air pollution, particularly in urban areas. The lack of greener, more sustainable transport options highlights the need for environmental improvements in the public transport system.

- **Recent Developments and Government Initiatives**

Digital Ticketing and Cashless Payments: There has been a gradual introduction of digital ticketing systems and cashless payments in the public bus sector, which aims to reduce transaction times and improve efficiency. However, widespread adoption remains slow due to technical and logistical challenges.

Modernization of Rail Services: The Sri Lankan government, with assistance from international donors, has initiated several projects to modernize the railway system, including track rehabilitation, the purchase of new locomotives, and the introduction of automated signaling systems. Despite these efforts, progress has been slow.

Public-Private Partnerships (PPPs): PPPs have been explored as a solution to improve bus services by involving private operators in route management and fleet maintenance. However, regulatory challenges and resistance from traditional operators have hindered significant progress.

Environmental Initiatives: Efforts to introduce electric buses and hybrid vehicles have been discussed as part of Sri Lanka's commitment to reducing carbon emissions. Pilot projects are underway, but the high initial costs and lack of charging infrastructure pose significant barriers.

V. POTENTIAL AI APPLICATIONS TO ENHANCE PUBLIC TRANSPORT IN SRI LANKA

Artificial Intelligence (AI) offers transformative solutions that can significantly improve public transport efficiency in Sri Lanka. Given the challenges such as congestion, outdated infrastructure, unreliable schedules, and poor service integration, AI can be pivotal in addressing these inefficiencies. Below are some potential AI applications that can enhance public transport in Sri Lanka:

- **Predictive Analytics for Demand Forecasting**

Predictive analytics can be used to forecast passenger demand by analyzing historical data, weather patterns, events, and socio-economic factors. Machine learning algorithms can predict peak travel times and passenger

loads, allowing operators to adjust bus and train frequencies accordingly.

Application: AI-driven demand forecasting can help optimize scheduling, reduce overcrowding, and ensure that resources are allocated efficiently, especially during peak hours.

Example: Implementing AI-based demand forecasting systems can help the Sri Lanka Transport Board (SLTB) and private operators schedule buses more effectively, minimizing wait times for passengers.

- . Route Optimization and Dynamic Scheduling

AI algorithms such as Genetic Algorithms, Neural Networks, and Reinforcement Learning can be used for route optimization by analyzing real-time traffic data, road conditions, and passenger patterns. Dynamic scheduling powered by AI can adjust routes and schedules in response to unexpected disruptions like accidents, roadblocks, or weather changes.

Application: Route optimization helps reduce travel time, avoid congestion, and improve overall service reliability. Dynamic scheduling ensures buses and trains adhere to their timetables, enhancing punctuality.

Example: Buses can be rerouted in real time to avoid traffic bottlenecks, and AI systems can dynamically adjust departure times to maintain optimal intervals between services.

- . Smart Ticketing and Contactless Payment Systems

AI can streamline ticketing and payment processes by integrating smart ticketing systems that support contactless payments and automated fare collection. Technologies like Natural Language Processing (NLP) and Computer Vision can facilitate seamless payment verification.

Application: Smart ticketing reduces boarding times, minimizes fare evasion, and provides valuable data on passenger behavior, which can be used to optimize services further.

Example: Implementing mobile app-based ticketing and QR code payments in buses and trains would simplify the payment process, reducing cash handling and enhancing passenger convenience.

- . AI-Powered Predictive Maintenance

Predictive maintenance leverages AI to analyze data from sensors installed on buses and trains to predict mechanical failures before they occur. Machine learning models can detect anomalies and suggest maintenance schedules, reducing the likelihood of breakdowns.

Application: Predictive maintenance can significantly improve fleet reliability, reduce downtime, and lower maintenance costs by preventing unexpected failures.

Example: For Sri Lanka Railways, predictive maintenance systems could monitor train components such as brakes, engines, and wheels, scheduling repairs before issues lead to service disruptions.

- Intelligent Traffic Management Systems

AI-driven traffic management systems use data from cameras, sensors, and GPS devices to monitor and control traffic flow in real time. These systems can optimize traffic signals, prioritize public transport, and manage congestion.

Application: By optimizing traffic light timings and managing intersections, buses can move more freely, reducing delays caused by road congestion.

Example: In Colombo, AI-based traffic management could prioritize buses at traffic signals during peak hours, improving journey times for public transport users.

- Autonomous and Semi-Autonomous Vehicles

AI can enable the development of autonomous or semi-autonomous public transport vehicles. While fully autonomous buses may be a long-term goal for Sri Lanka, semi-autonomous technologies such as automated braking, lane-keeping assistance, and collision avoidance can enhance safety and efficiency.

Application: Semi-autonomous features can reduce human error, improve safety, and optimize driving patterns to save fuel.

Example: Pilot projects with semi-autonomous buses could be tested on specific routes to evaluate their effectiveness and safety in Sri Lankan conditions.

- . AI-Enhanced Passenger Information Systems

AI can improve passenger information systems by providing real-time updates on bus and train schedules, expected arrival times, and service disruptions. Chatbots and voice assistants powered by AI can offer personalized assistance to commuters, helping them plan their journeys more effectively.

Application: Real-time information systems enhance the commuter experience by reducing uncertainty and enabling passengers to make informed travel decisions.

Example: Deploying AI-driven mobile apps that provide real-time bus and train tracking can help passengers plan their journeys better, reducing waiting times.

- . Data-Driven Decision Making and Policy Planning

AI can analyze large datasets generated by public transport systems to provide insights for policymakers. These insights can be used to improve route planning, optimize resource allocation, and develop targeted interventions to address specific challenges.

Application: Data-driven decision-making helps transport authorities develop policies that are responsive to commuter needs and operational realities.

Example: Analysis of passenger data could help identify underserved areas, prompting the introduction of new routes or increased frequency of services in high-demand locations.

- AI for Incident Detection and Safety Management

AI-powered video analytics can monitor public transport vehicles for incidents such as overcrowding, fights, or accidents. Computer Vision systems can detect anomalies and alert operators in real time, enhancing safety and security on public transport.

Application: Incident detection systems improve safety by providing rapid response capabilities, ensuring that issues are addressed promptly.

Example: Implementing AI-driven surveillance on buses and trains can help detect overcrowding or unauthorized boarding, enhancing passenger safety.

- . Personalized Travel Recommendations

AI can offer personalized travel recommendations based on user preferences, historical travel data, and current traffic conditions. This can include suggesting the quickest routes, alternative modes of transport, or off-peak travel times.

Application: Personalized travel recommendations enhance the commuter experience by providing tailored information that meets individual needs.

Example: Mobile apps could use AI to recommend the best travel options for passengers based on real-time data, optimizing their daily commutes.

Implementing these AI applications can revolutionize public transport in Sri Lanka by addressing current inefficiencies, improving service quality, and enhancing the overall commuter experience. Collaboration between government, private operators, and technology providers is essential to successfully deploy these solutions and transform Sri Lanka's public transport system into a modern, efficient, and user-friendly service.

VI. IMPLEMENTATION CHALLENGES IN SRI LANKA

Data Availability and Quality Issues related to data collection, sharing, and integration across different transport modes.

Infrastructure Limitations- Challenges in upgrading existing infrastructure to support AI technologies.

Cost and Funding- Financial barriers to implementing AI-driven solutions.

Public Acceptance and Privacy Concerns: Addressing privacy issues related to data collection and the public's trust in AI.

VII. RECOMMENDATIONS

To effectively implement Artificial Intelligence (AI) and improve public transport efficiency in Sri Lanka, several strategic recommendations must be considered. These recommendations aim to address the existing challenges while ensuring that the integration of AI technology leads to a sustainable, efficient, and passenger-friendly transport system.

1. Develop a National AI Strategy for Public Transport

Sri Lanka should establish a clear and comprehensive national AI strategy focused on public transport. This strategy should outline the key goals, objectives, and timeline for AI adoption across various modes of transport, including buses, trains, and other public transit systems.

Action: The government, in collaboration with transport authorities, private operators, and technology firms, should create an AI roadmap that addresses specific transport challenges.

Outcome: A well-defined strategy will provide a framework for the adoption of AI and ensure that stakeholders are aligned on goals such as reducing congestion, improving reliability, and enhancing commuter experience.

2. Invest in Digital Infrastructure and Data Collection

AI-driven transport systems rely heavily on robust digital infrastructure and data collection. Sri Lanka needs to upgrade its transport infrastructure with sensors, GPS, Internet of Things (IoT) devices, and automated ticketing systems that generate the necessary data for AI applications.

Action: Establish a national data platform where real-time data from buses, trains, traffic, and passenger flows are collected, stored, and analyzed.

Outcome: A reliable data infrastructure will serve as the foundation for predictive analytics, route

optimization, and other AI applications, enabling more effective decision-making and service enhancements.

3. Implement AI for Real-Time Traffic and Route Optimization

AI can be used to optimize bus and train routes by analyzing real-time traffic data, road conditions, and passenger patterns. Sri Lanka should adopt AI-powered route optimization systems to reduce delays and avoid traffic bottlenecks.

Action: Install AI-based traffic management systems in high-traffic areas to dynamically adjust bus routes and manage congestion.

Outcome: Reduced travel times, increased efficiency, and improved punctuality of buses and trains during peak hours.

4. Introduce AI-Driven Predictive Maintenance Systems

Predictive maintenance can drastically reduce the number of breakdowns and disruptions in public transport by using AI to predict mechanical failures in buses and trains before they occur.

Action: Equip buses and trains with IoT sensors that monitor the health of key components such as engines, brakes, and electrical systems. AI models should analyze the data and trigger maintenance before issues become critical.

Outcome: Improved fleet reliability, reduced operational costs, and fewer service disruptions.

5. Adopt AI for Demand Forecasting and Dynamic Scheduling

AI-driven demand forecasting can help transport operators anticipate passenger demand and adjust schedules dynamically. This will reduce overcrowding and improve resource allocation by deploying additional buses or trains when and where they are most needed.

Action: Develop machine learning models to analyze historical data and predict daily commuter patterns. Use these insights to schedule more services during peak hours and reduce service frequency during off-peak times.

Outcome: Efficient scheduling and resource allocation, leading to reduced wait times, improved passenger satisfaction, and optimized operating costs.

6. Expand Smart Ticketing and Contactless Payment Systems

AI can help streamline the ticketing process through the adoption of smart ticketing systems that use

contactless payments. This can enhance convenience for passengers and provide real-time data for operators to further optimize services.

Action: Implement AI-powered mobile payment solutions that allow commuters to use their smartphones or smart cards for ticketing across all modes of public transport.

Outcome: Faster boarding times, reduced cash handling, and improved operational efficiency with the added benefit of better passenger behavior data.

7. Launch Pilot Projects to Test AI Applications

Before large-scale implementation, Sri Lanka should launch pilot projects to test various AI applications, such as predictive maintenance, route optimization, and demand forecasting, in specific urban and rural areas. This will provide valuable insights into the effectiveness of these technologies under local conditions.

Action: Identify key bus routes, train lines, or high-traffic corridors in cities like Colombo for AI pilot projects. Assess the impact of AI on efficiency, passenger satisfaction, and cost savings.

Outcome: Data-driven insights that can guide full-scale implementation, minimizing the risk of failure and ensuring that AI solutions are tailored to local challenges.

8. Foster Public-Private Partnerships (PPPs) for AI Integration

Collaborating with private technology firms, AI startups, and international organizations can help Sri Lanka adopt AI in public transport more effectively. Public-private partnerships (PPPs) can facilitate technology transfer, funding, and expertise.

Action: The government should incentivize partnerships between transport operators and AI technology providers by offering grants, tax breaks, and technical support for innovation in public transport.

Outcome: Faster adoption of cutting-edge AI technologies, reduced public expenditure on infrastructure upgrades, and access to global expertise.

9. Provide Training and Capacity Building for Transport Operators

AI adoption requires skilled personnel who can manage, maintain, and operate AI systems. Training programs should be developed to upskill existing transport staff and equip them with the knowledge needed to manage AI-driven systems.

Action: Introduce AI-focused training programs for public transport operators, engineers, and policymakers

to ensure they understand how to use AI for scheduling, route optimization, and maintenance.

Outcome: A workforce that is well-equipped to handle the operational demands of an AI-enhanced public transport system, ensuring smooth implementation and operation.

10. Address Legal, Ethical, and Regulatory Concerns

AI adoption in public transport brings challenges related to data privacy, security, and ethics. The government must establish clear regulations governing the collection, use, and sharing of data to ensure transparency and protect commuter privacy.

Action: Develop a legal framework to regulate AI applications in public transport, focusing on data protection, safety standards, and accountability.

Outcome: A secure, transparent, and ethically sound AI-driven transport system that garners public trust and adheres to international best practices.

11. Promote Public Awareness and Engagement

To ensure successful AI adoption in public transport, it is essential to engage the public and create awareness about the benefits of AI-driven systems. Public education campaigns can help overcome resistance to technological change and build trust in AI systems.

Action: Launch public awareness campaigns highlighting the advantages of AI in improving transport efficiency, safety, and convenience. Engage commuters through social media, workshops, and community events.

Outcome: Increased public acceptance of AI-driven systems and greater engagement from commuters in using smart ticketing, mobile apps, and other AI-powered services.

VIII. CONCLUSION

Leveraging AI to enhance public transport efficiency in Sri Lanka requires a holistic approach that includes strategic planning, investment in infrastructure, pilot testing, and public engagement. By adopting these



recommendations, Sri Lanka can create a more reliable, efficient, and modern public transport system that meets the needs of its citizens while addressing current challenges like congestion, service delays, and resource inefficiencies. AI has the potential to transform public transport and significantly improve the quality of life for commuters across the country.

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IX Author Biography/ies



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Optimizing Cold Chain Management In Sri Lanka's Pharmaceutical Industry: A Fuzzy Logic Approach To Enhancing Transportation And Storage

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Abstract

In the logistics industry, the cold chain system plays a major role in ensuring the quality and safety of temperature-sensitive products such as pharmaceutical items and other perishable goods (Vukašin Pajić, Andrejić, and Chatterjee, 2024). This study focuses on optimizing the cold chain management (CCM) within Sri Lanka's private sector pharmaceutical industry with an emphasis on storage and transportation. Rout (2024) indicates that high costs associated with the cold chain process, transportation and storage inefficiencies, lack of skilled professionals, and regulatory inconsistencies can hinder efficiency and complicate operations. The objective is to enhance the decision-making process and reduce product spoilage during storing and transporting functions while ensuring that medications reach patients in optimal condition and protect the merchantable quality. Through a comprehensive literature review, the key variables were identified, the use of the fuzzy logic framework was highlighted, and the challenges in maintaining the quality were addressed. The study contributes to the existing body of knowledge by applying this novel methodology, which can be used by any developing country that has logistical challenges and other limitations. The findings give practical insights into the concerns of the decision-makers, providing a blueprint focusing on travel time, packaging, skillful personnel, temperature maintenance, and infrastructure availability. The study couples two intangible benefits and identifies three extended benefit scales, such as

low, medium, and high. In conclusion, the effective use of fuzzy logic in enhancing CCM offers an adaptive and structured method for improving product quality and provides a valuable tool for improving the management of temperature-sensitive products.

Keywords: Cold Chain Management, Fuzzy Logic, Pharmaceuticals, Transportation, Storage, Private Sector

I. INTRODUCTION

A. Background of the study

The cold chain system can be identified as the observed business process in the global value chain, as it ensures the provision of appropriate storage and transportation facilities for the temperature-sensitive products, which are pharmaceuticals and perishable foods (Vukašin Pajić, Andrejić, and Chatterjee, 2024). As the nomenclature implies, CCM means a logistics process specifically for the goods that need to maintain the required sustained refrigerated temperature to protect the product quality preservation and to ensure the potency of the products. It's a process of a chain of tasks that contains the production, storage, and transportation of goods along the cold chain. The pharmaceutical and food industries highly rely on this concept. The pharmaceutical industry stands among other cold chain industries that need to maintain the highest operational standards throughout the value chain. From the manufacturing point to the

consumption point, products should be handled carefully to ensure the potency is preserved. For most of drugs, the temperature should be maintained between 15 and 25 degrees Celcius, and for vaccines, insulin, and blood products, temperatures should be maintained between 2 and 8 degrees Celcius in the cold chain (www.efl3pl.global, 2024). Hence the temperature requirements are directly affected

by the product efficacy and the safety of the patients. In developing economies like Sri Lanka, cold supply chains are mostly concerned about the logistics operations, warehouse designs, technology, and potential service providers. In the absence of efficient CCM, can lead tot damaging the livelihood of the patients and the communities.

B. Contextual meanings

CCM - Cold Chain Management

MQ - Merchantable Quality

C. Research Problem

Sri Lanka's pharmaceutical industry faces significant challenges when ensuring the safety and quality of temperature-sensitive medications throughout the complex CCM. To guarantee that the patients get quality products, this research focuses on identifying and implementing the strategies that are optimizing Sri Lanka's CCM process, specifically this focus on transportation and the storage cold chain functions.

D. Objectives of the study

This study focuses on optimizing cold chain management in Sri Lanka's pharmaceutical industry through the functions of storing and transportation using fuzzy logic. Moreover, the study is concerned with product characteristics and provides strategic recommendations to industry decision-makers.

1. Create a fuzzy logic framework to measure the benefit realization to enhance the merchantable quality of the products and the efficiency of the cold chain process in pharmaceuticals.
2. Evaluate the impact of optimized storage and transportation on maintaining product potency and reducing spoilage.

E. Significance of the study

Research on optimizing the CCM process holds significant value in different ways. Such as, it can improve the medication quality and the public sector's life. This can reduce the spoilage

of the product and ensure the product will reach the required patients with full potency and reduce the medicine degradation with the potential adverse reactions. Apart from that, this study leads to identifying the areas that need to be more efficient in Sri Lanka's pharmaceutical cold supply chain, which leads to increased efficiencies with cost savings. This is a pioneering approach that leads to exploring the fuzzy logic in Sri Lanka's pharmaceutical industry. The results are not only used by Sri Lanka but also by other developing countries that are struggling with the same cold chain issues. Therefore, this has become a blueprint that shows how to handle life-saving medications especially in the storing and transporting functions in the CCM process. The overall impact of this study is not only to benefit public health but also to make sure to have a cost-effective healthcare system. The fuzzy logic will impact the decisions of pharmaceutical managers in terms of operational decisions. The strategic decision-level thinkers will be impacted by the fuzzy outcome in quantifying their benefits, such as merchantable quality (MQ) of merchandise, pricing, and other economies.

F. Scope

Cold chain management can be identified as a business function in the global value chain it identifies as an industry, and this is a subclass of supply chain management. CCM is widely applied in foods, beverages, and perishable goods like fresh fish, vegetables, and fruits, and today our study is on pharmaceuticals, medical drugs, vaccines, and emergency medicines. However, this study focuses on the pharmaceutical industry only with the interest of understanding the measurement of benefits in this industry. The study is intentionally

observing the private sector companies because the government does not reveal feasible literature for the study. The supplier of pharmaceuticals is the central focus, which thereby excludes the other parties in the supply chain.

G. Limitations of the study

There are three limitations, namely methodological, practical, and temporal. This study is fuzzy logic driven, leading to a novel methodology that is outside of the traditional methodologies like quantitative and qualitative. Practically, we focus only on pharmaceuticals, thereby limiting ourselves to a separate sector in medical supplies. Temporally this study is only cross-sectional and not continuous in its timeline approach.

II. LITERATURE REVIEW

For decades, temperature control product management has been a crucial area that needs to be more focused protecting product efficacy, and quality and adhering to the product's regulations required by the governments. CCM mainly affects the pharmaceutical industry and the fresh foods industry. In countries that are not maintaining the CCM properly, 200 million tons of food are damaged before they reach the market (Andrejić and Vukašin Pajić, 2024). Global spending on medications is approximately US \$ 1.25 billion in 2019, and by the year 2024 it will increase to US \$ 1.59 billion as a reason for the increase in the world's population as well (Soodeh Jahdi et al., 2024). In terms of the high medical expenses, it is compulsory to practice a proper CCM to avoid any unnecessary expenses. Logistics suppliers who deal with low-temperature storage products need a proper selection and evaluation process to reduce the waste of medicines due to poor transportation and storage (Hien and Thanh, 2022).

Existing literature provides valuable insights regarding the cold chain issues relevant to the developed countries that established the logistics networks. The studies often overlook unique challenges in developing countries because of the limited infrastructure, climatic changes, and

logistical issues that can adversely impact the cold chain process (Gligor et al., 2018). The methodological gap between the studies highlights that existing literature consists of quantitative assessments and does not fully capture the qualitative factors because human factor involvement is at a considerable stage for the decision-making process in this industry.

Cold chain management in the pharmaceutical industry faces numerous issues in developing countries like Sri Lanka with the lack of temperature control systems in the customs, unpredictable lead times, and regulatory delays (Gunawardana & Herath, 2020). To address these issues, fuzzy logic controllers have been proposed for the humidity and temperature control in pharmaceutical warehouses valuing the stable and efficient performance (Elias et al., 2018). Fuzzy logic can be used to analyze and then prioritize the factors affecting the performance of the cold chain in areas such as packaging, transportation, and storage (Hien and Thanh, 2022). The effectiveness of pharmaceutical items is highly based on mainly two critical functions, such as, storage and efficient distribution. These functions ensure that the medications maintain their potency and reach the end customer safely. The storing methods, such as refrigerators, cold chambers, freezers, cold boxes, and carriers, are based on the medication type, which means the temperature level and the storing containers are different from each other. Storing and transportation functions need specific quality checks in each step in the cold supply chain process, and fuzzy logic can be used to identify the factors that are optimizing the CCM. Traditional quantitative methods often rely on more precise data, and these approaches can be more applicable in stable environments or minimum variability as seen in the developed countries. However, these struggle to accommodate developing countries like Sri Lanka. The use of fuzzy logic in this study can accommodate the uncertainties of the pharmaceutical supply chain such as temperature fluctuations and product degradation, which traditional models overlook.

Significant cost savings in inventory management can be achieved as the study allows for more accurate demand and resource allocation. This study not only contributes to the existing body of knowledge but also provides practical solutions for optimizing the CCM in the pharmaceutical industry.

III. METHODOLOGY

The methodology in this research used the extended AI version called fuzzy logic. This method supports decision-makers in finding the optimum solution and from that can measure the qualitative intangible benefits. In this study fuzzy logic couples two intangible benefits and identifies three extended benefit scale such as low, medium and high. The variables which are concerned with storage, transportation and specifically product characteristics evaluate and find the benefits realization through that. The variables and the indicators were identified through a thorough literature review and the study is focused on the private sector hence the data from the government pharmaceutical industry were not accessible. As per figure 1, the dependent and independent variables are mentioned. Table 1 depicts how these variables

and the indicators are derived by using the existing literature.

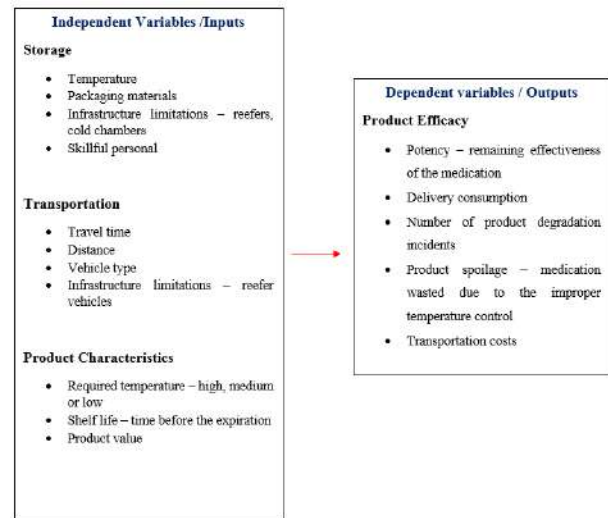


Figure 1: Dependent and Independent Variables of the study

Source : Constructed by researchers (2024)

A. Operationalization of fuzzy variables

Table 1: Classification of variables with literature review

Variables	Dimensions	Indicators	Literature
IV 1	Storage	Temperature	Pajić et al. (2024)
		Packaging materials	Pajić et al. (2024)
		Infrastructure limitations – reefers, cold chambers	Hien and Thanh (2022)
		Skillful personal	Hien and Thanh (2022)
IV 2	Transport	Travel time	Hien and Thanh (2022)
		Distance	Hien and Thanh (2022)
		Vehicle type	Hien and Thanh (2022)
		Infrastructure limitations (reefer vehicles)	Hien and Thanh (2022)
IV 3	Product characteristics	Required temperature	Vukašin Pajić, Andrejić and Chatterjee (2024)
		Shelf life (time before the expiration)	Vukašin Pajić, Andrejić and Chatterjee (2024)
		Product value	Ashok, Brison and LeTallec (2017)
DV 1	Product Efficacy	Potency	Hien and Thanh (2022)
		Delivery Consumption	Vukašin Pajić, Andrejić and Chatterjee (2024)
		Product Degradation	Vukašin Pajić, Andrejić and Chatterjee (2024)
		Product spoilage	Vukašin Pajić, Andrejić and Chatterjee (2024)
		Transportation costs	Ping Zhang et al. (2021)

IV. RESULTS AND DISCUSSION

By measuring the benefits of cold chain management and evaluating the benefit realization, which assures the efficacy of the pharmaceuticals, we can achieve the objectives of the study. Below are the outcomes of several variables and the interpretations of fuzzy logic and its theoretical applications in the industry.

A. Fuzzy inference system of the pharmaceutical industry for fuzzy variables: Travel time and temperature

If travel time is “low” & temperature is “low” the CCM benefit realization is “NEVER”

If travel time is “low” & temperature is “medium” the CCM benefit realization is “SELDOM”

If travel time is “low” & temperature is “high” the CCM benefit realization is “SOMETIMES”

If travel time is “medium” & temperature is “high” the CCM benefit realization is “MOST OCCASIONS”

If travel time is “medium” & temperature is “medium” the CCM benefit realization is “SOMETIMES”

If travel time is “medium” & temperature is “low” the CCM benefit realization is “SELDOM”

If travel time is “high” & temperature is “low” the CCM benefit realization is “SOMETIMES”

If travel time is “high” & temperature is “medium” the CCM benefit realization is “MOST OCCASIONS”

If travel time is “high” & temperature is “high” the CCM benefit realization is “ALWAYS”

B. Interpretation of Fuzzy logic & its theoretical application in the pharmaceutical industry

Travel time can vary relatively due to factors like traffic conditions, road conditions, logistical delays, and distance. This can increase the risk of the cold chain process and the product efficacy,

mainly if the travel time takes more than anticipated. Saw (2023) identified using fuzzy logic that trip attributes have more impact than socio-economic characteristics in maintaining product quality. The travel time is categorized into three levels - low, medium and high - as per the fuzzy logic, and this allows us to verify the impact of the changes in the travel time, which can affect the temperature changes and the quality of the products. Product efficacy and safety factors can change based on temperature changes due to inadequate temperature monitoring, product malfunctioning, and environmental factors (Shafaat et al., 2013). Optimal, moderate, and suboptimal level changes in the temperature were identified under fuzzy logic as low, medium and high. The study assesses its impact on the quality, providing nuanced analysis rather than using traditional deterministic models.

It is revealed that if travel time is low & temperature is low, the CCM benefit realization is “NEVER”. However, the duration of transportation is low, and the temperature accuracy of the cooling process is low; the MQ of merchandise pharmaceuticals can't be achieved to the expectations of the industrial experts. If travel time is low & temperature is medium, the CCM benefit realization is “SELDOM. If the duration of the transport is low and temperature accuracy is not up to industrial norms, then the achievement of quality is not to the exact desire of the cold chain managers. The fuzzy logic explains that if travel time is “low” & temperature is “high,” the CCM benefit realization is “SOMETIMES”. This is not seen in the industry. The practice is that when time is less and cooling temperature accuracy is high, then the quality of the drugs is to the expectation of front liners of management in the industry who supervise the quality.

In the fuzzy logic, it describes that the travel time is medium and the temperature is high; the benefit realization of fuzzy logic is “MOST OCCASIONS”. In these cases, cold chain benefits are achieved most of the time because

reasonable travel times and effective temperature control ensure the pharmaceuticals maintain high quality during transportation while ensuring the industry standards. Then, if the travel time is medium and the temperature accuracy is also medium then the benefit realization of CCM is “SOMETIMES”. Cold chain benefits can be achieved intermittently, and that means that due to not maintaining the accurate temperature during transportation, quality standards are not fully met. If the travel time is in a medium controlling level and the temperature is at an inadequate level that means it is at the lower level, then the benefit realization is “SELDOM”. That means the benefits of the CCM are barely realized, and the quality with the effectiveness of pharmaceuticals are often falls off the industry expectations. Then the travel time is high, and the temperature accuracy is at a lower level, then the CCM benefit realization is “SOMETIMES”. That simply means travel time is at a higher level, and the temperature control is at a lower level then benefits are occasionally realized. Even though the process has longer travel durations with suboptimal temperature control times, still there are some occasions when pharmaceuticals maintain acceptable quality. The next outcome is that travel duration is highly controlled, and the temperature control is moderate; then the benefits can be achieved on the “MOST OCCASIONS”. This implies that the travel duration is highly controlled, and effective temperature control ensures the product quality is constantly maintained. The final outcome is that travel time is high, and the temperature accuracy is high then the benefit realization is “ALWAYS”. This indicates that the strongest temperature measures with a minimum travel time ensure that the quality and the efficacy of the pharmaceuticals are achieved always.

C. Fuzzy inference system of the pharmaceutical industry for fuzzy variables: skilful personnel and packaging material

Table 2 : Fuzzy Logic Impact on skilled personal and packaging variables

Packaging	Skillful personal			
		LOW	MEDIUM	HIGH
	LOW	VERY LOW	LOW	MEDIUM
	MEDIUM	LOW	MEDIUM	HIGH
	HIGH	MEDIUM	HIGH	VERY HIGH

Source : Constructed by researchers (2024)

Personal skill level is important for proper handling, decision- making and monitoring of pharmaceuticals (Rathore et al., 2012). Variability can arise due to inadequate experience and training. Mahendrawathi et al. (2011) indicate that fuzzy classifications can enhance product quality by considering qualitative factors like human skills and experiences. The fuzzy model categorises the skill level into low, medium, and high and evaluates how variations in personal skill affect the quality of CCM while providing more sophisticated analysis. Das et al. (2018) indicate that selecting the appropriate packaging techniques and materials ensures the product's shelf life and product stability, which helps to protect its efficacy. Variability in packaging can differ based on material properties and design for protectiveness. Fuzzy logic categorized the packaging strategies into low, medium, and high, which influence the overall effectiveness and stability of the process.

As per table 2, if the employee skills are low and the product packaging is at a minimum level, then the benefit realization is “VERY LOW”. That means, both factors are at an inadequate level, like not having proper product handling expertise with robust packaging; pharmaceuticals products’ quality cannot be realized. Then the packaging is low, and the employee skills are in the middle range, then the benefits realization is “LOW”. With sufficient skilled people, moderate packaging standards limit the merchantability of the pharmaceuticals. Low packaging with high personal expertise generates a “MEDIUM” level benefit realization and that means, properly skilled personnel can mitigate some risks, but without proper packaging can make barriers to achieving merchantability. With moderate - level packaging of the products and high personal expertise, the CCM benefit realization is “HIGH”. That shows, that a balance of decent

packaging with skilled people handling the products properly enhances the reliability of the pharmaceuticals by enhancing their merchantability. When both packaging and the personal expertise levels are at a moderate level then the benefit realization is also at a “MEDIUM” level. This indicates that the consistency of the merchantability of the products can vary if there is reasonable packaging and expertise. Packaging efficiency is at a medium level, and the personal skills are at a lower stage than the merchantability of the product is “LOW”. Even with the proper packaging level with insufficient skills in handling can lead to challenges in maintaining the MQ. A high level of packaging with a low skillful people can be a reason to generate a benefit realization of the “MEDIUM” stage. That implies while good packaging helps, lacking skilled personnel can hinder the maintaining of the merchantability of the pharmaceutical products. With high packaging quality and moderate personal expertise, we can generate “HIGH” benefits realization. Competent product handling with the proper product packaging can enhance the merchantable product quality. If both product packaging and the skills of the workforce are at the highest level, then the benefit realization is “VERY HIGH.” That means, controlling both these factors at an efficient level ensures the consistent maintenance of the pharmaceutical products’ quality.

D. Fuzzy inference system of the pharmaceutical industry for fuzzy variables: temperature and infrastructure availability

Table 3 : Fuzzy logic impact on temperature and infrastructure availability variables

Infrastructure availability	Temperature			
		LOW	MEDIUM	HIGH
	LOW	VERY LOW	LOW	MODERATE
	MEDIUM	LOW	MODERATE	HIGH
	HIGH	MODERATE	HIGH	VERY HIGH

Source : Constructed by researchers (2024)

Proper infrastructure has assured the product quality during the transportation and storing of

pharmaceutical items with the required temperature range, ensuring the efficacy and product quality (Panigrahi et al., 2024). Risk assessment, such as monitoring and also handling and decision- making in infrastructure development, can be done using fuzzy logic. And also, fuzzy logic applications identify ways of optimizing resource allocation and infrastructure utilization (Ren et al., 2024).

When both infrastructure availability and temperature adequacy factors are at an inadequate level as depicted in table 3, then the cold chain benefit realization is “VERY LOW QUALITY.” It causes a reduction in the perceived quality of the products by not having both factors at an adequate level. If the infrastructure availability is at the low range and the temperature accuracy is at the medium range, then the products are at a “LOW QUALITY”. Limitations are generated in maintaining the product quality due to the inadequate infrastructure availability despite somewhat better temperature accuracy. Benefit realization can be “MODERATE” when the infrastructure is lower and the temperature accuracy level is high . Hence the temperature control is at a favorable level, but the limitation in the infrastructure can pose challenges to achieving the quality products. “HIGH QUALITY” products can be maintained when the infrastructure availability is at a medium range with the temperature control of the products at a higher level. Reasonably reliable product quality can be maintained if both factors are equally controlling and the output is “MODERATE QUALITY” products. The challenges in maintaining the temperature accuracy and the infrastructure availability are at a medium range then the products are at “LOW QUALITY”. Proper infrastructure with lower temperature accuracy generates the “MODERATE” level quality products. Inadequate temperature control limits the ability to provide a quality product even though it has the best infrastructure availability. High infrastructure availability with moderate temperature accuracy leads to a “HIGH QUALITY” product due to the good conditions of the products. Then both these factors are highly maintaining the product quality, which is “VERY HIGH” and optimal conditions of the products can be maintained by controlling these factors at a higher level.

E. Illustration for optimizing quality in the pharmaceuticals

Fuzzy logic says that quality has five dimensions. These are “never, seldom, sometimes, on most occasion, and always.” The industry can experience these fuzzy linguistics quantifiers in five levels. However, in the industry, it is difficult to interpret these quantifiers in practice because of the practical deviations. Profitability often clashes with the algorithm perceptions in the decision-making process, and the subjective fuzzy logic interpretations can impact the operational efficiency of the CCM. Despite these fuzzy logic offers a structured method to enhance the processes. Industry experts can use risk mitigation strategies with adaptive control mechanisms by depicting the fuzzy variables/ logic.

F. Achievement of objectives

This study successfully achieved its objectives, such as measuring the benefits of a cold supply chain and evaluating those benefits of using fuzzy logic. The novel approach is used to optimize the CCM by focusing on the storing and transportation functions in the cold chain process. The study addresses the critical challenges that arise when maintaining the pharmaceuticals items quality and efficacy. Implementing this fuzzy logic guides the decision-makers in the industry to enhance the process efficiency, ensuring the medicines reach the patients in full potency while reducing the product spoilage as well. This approach is not only robust for the pharmaceutical industry but also acts as a blueprint for other temperature-sensitive product industries.

V. CONCLUSION

This research was conducted on optimizing cold chain management in Sri Lanka’s pharmaceutical industry with the use of fuzzy logic. Developed a fuzzy logic framework that supports the achievement of the objectives of the study that enhances the decision-making in the transportation and storage functions which are critical to maintaining the efficacy and the quality of the products. Systematically identify the variables in these two functions such as temperature control, travel time, packaging quality, personnel skill levels and infrastructure availability. The fuzzy logic provides a more

flexible and nuanced approach than the traditional methods which is critical to account for the uncertainties inherent in real-world scenarios.

This study stands on existing literature focusing on the challenges faced by the pharmaceutical industries in the developing countries, which pronounced the environmental factors, lack of infrastructure availability, and other logistical constraints. Significantly addressed the gap by applying the fuzzy logic to manage the complexities, highlighting that it can contribute to reducing product spoilage, enhancing reliability, and ensuring the medications reach the end users with their full potency level. The findings of the study directly apply to any other developing countries facing similar challenges.

Through the lens of fuzzy logic, shows the opportunity to optimize the CCM, which helps to enhance the decision-making process by providing quality products efficiently. It provides a structured method for controlling the quality of temperature-sensitive products. Visual representations play a pivotal role in providing the best picture of the industry concerns. As the industry navigates the complexities, fuzzy logic supports the responsive and adaptive management practices. In that case, fuzzy logic supports maintaining the stringent product and process quality standards while optimizing the utilization of the resources efficiently. Therefore, optimizing the sustainable cold supply chain in the Sri Lankan pharmaceutical industry focused on the fuzzy model for transportation and storing functions. This helps the industry decision-makers to provide quality pharmaceutical products, ensuring the product’s efficacy for the end users.

VI. FUTURE RESEARCH

The study has focused mainly on pharmaceuticals in the cold supply chain. The futuristic value is focusing on other industries that utilize CCM, such as fresh foods and beverages. Also, a fuzzy model with AI technology can be used to measure the MQ of the temperature-sensitive products to get the best outcome to provide quality products.

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ML-POWERED APPLICATIONS FOR PREDICTING FLIGHT DELAYS INSIGHTS FROM THE AVIATION INDUSTRY IN SRI LANKA

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Abstract - Flight delays in Sri Lanka's aviation industry significantly impact operational aspects, financials, and passenger satisfaction. Factors such as maintenance issues, weather conditions, airport congestion, and air traffic flow contribute to delays. A prediction system had replaced the traditional method of analysing delays with ML algorithms, including Cat Boost and others. ML is a subset of artificial intelligence that uses technology to minimize the consequences of flight delays. Literature verified that a predictive model deployed proactive actions to minimize delays. The study objectives were to analyze variables and identify where ML adoption is required to mitigate flight delay repercussions using fuzzy logic theory. Fuzzy is used to quantify the qualitative benefits of the airline industry concerning the degree of occurrence of delays. We utilized two variables to realize the flight status through the fuzzy logic approach. The results were categorized into five fuzzy linguistic variables in flight status: late, very late, moderately late, cancelled, and on-time performance, evident in several specific study cases. Based on these findings, the study proposes utilizing machine learning (ML) algorithms associated with the fuzzy logic system to predict flight delays with two primary outcomes: delayed or cancelled. The study concludes that an ML-powered predictive system for robust air operations is essential. It will augment cost savings and customer satisfaction in the aviation industry in Sri Lanka. The technical analysis of the algorithm and the model deployment in the aviation fields is futuristic.

Keywords— Artificial Intelligence (AI), Flight Delay, Machine Learning (ML), Fuzzy inference system, Benefits Realization

Glossary

Artificial Intelligence (AI) refers to the ability of technological devices to learn, create, discover, and analyze things from past experiences associated with intellectual characteristics. Flight delays mean late arrivals and later departures of aircraft than their scheduled time. Aviation refers to the activities and operations of the airline industry associated with both sectors of commercial and military flights. Machine learning (ML) is a subset of artificial intelligence that can complete complex tasks in the way humans resolve them.

I. INTRODUCTION

According to a scholar in the field, in late 2022, a series of flight delays caused a substantial loss of USD 6 million to Sri Lankan Airlines, which was directly linked to passenger inconvenience and financial deficit. This exacerbated the allowances and compensation of employees in the Sri Lankan aviation industry in 2023. The main influences for flight delays are maintenance delays, technical errors, insufficient technical crew, extreme weather conditions, airport congestion, air traffic, etc. Sri Lankan aviation industry currently cooperates with

CRS (Computerized Reservation Systems), AOCC (Airport Operations Control Center), and FIDS (Flight Information Display Systems) to minimize the impact of on-time performance based on real-time updates. However, these systems may not have been effective in addressing cost efficiency and passenger loyalty yet. In this light, novel technologies and ideologies have been embraced to address physical and human resource constraints. Utilizing the Fuzzy Cognitive Diagnosis framework, this study determined the most influential variables as the unavailability of maintenance crew and unavailability of spare parts contributing to flight disruptions and pinpointed the specific domains where machine learning techniques are required as devised solutions for problems associated with flight delays.

The specific research objectives are,

- To apply fuzzy logic to analyze the variables relating to the aviation industry and measure flight delays.
- To determine where the airline should adopt ML applications in conjunction with the fuzzy inference system to detect flight delays while strengthening the passenger experience and cost efficiency.

A. Significance of the study

The paper has two aspects. They are theoretical significance and practical significance. The theoretical significance is the use of the fuzzy theoretical model and the fuzzy model's application. The practical aspect is that competition is emerging in this industry, and the delays are a major cause of achieving this contractual obligation. In this case, the flight delays have caused a loss of goodwill, customer dissatisfaction, a drop in cost savings over the years, and overall, not achieving the desired benefits.

B. Scope of the research

As the theoretical scope of fuzzy logic application in terms of fuzzy benefit management in the aviation industry is also applied.

The practical scope: The study is not applied to military logistics but only to fixed-wing commercial airlines. To provide a tangible solution to the research problem, we focus on the AI and related models to predict future flight delays. The AI prediction software used in the company is not limited to data scheduling via information management systems.

C. Limitations

This research does not consider problems in a specific airport in Sri Lanka, its perspective encompasses the whole aviation industry. Therefore, the outcome of this research may aid the entire aviation industry in the world. This research focuses on identifying strategies to overcome flight delay issues in the aviation industry in Sri Lanka. Flight delays are a

communal problem for various flight operations, such as commercial flights, military flights, and Heli tours operationalized by the Sri Lanka Air Force. To comprehensively analyze this research, flight delays in commercial flight operations have been discussed by excluding other flight categories. Furthermore, the temporal limitation timeline is that the study is cross-sectional. This means the flight delays are being studied within 3 to 4 months and not an annual continuous study. Therefore, the recurrence of the delays cannot be measured in this study. The study targets the aviation industry and limits its application to commercial aviation. This is because Sri Lankan airlines represent commercial aviation and exclude themselves from the broader organizations like Heli Tours which operate helicopters, amphibious aircraft, and drone operators. The defuzzification step has been excluded in this research.

D. Research Question

- A. How can the fuzzy inference system be applied to identify the situation in the aviation industry in Sri Lanka where the adaptation of ML would be the most beneficial in predicting and mitigating flight schedule failures?
- B.

II. LITERATURE REVIEW

International Airlines is in an alliance with One World. One World is a specific airline alliance that is a collaboration between Asia-Pacific, the Middle East, and the Asian region. One World has Sri Lanka as its player in the alliance with the fifth position among other contract partners. The airline industry in Sri Lanka is monopolized by the National carrier Sri Lanka Airlines. The airline company is located in Bandaranaike International Airport, and its flights are operated in Katunayake. Flight delays are seen due to several issues such as spare part issues, shortage of technical crew, airport congestion, and extreme weather conditions (Chakrabarty N. 2019).

It is observed in seminal studies that one of the biggest reasons for flight delays is maintenance delays due to technical errors (Nuttall, 2024). He explained that the high lead time for procuring spare parts is causing this problem. Other airlines have the facility to obtain spare parts within 24 hours, and that could not be achieved in the Sri Lankan context. According to the seminal literature, Lahiru Doloswala, (2023) explicated that the airline highlighted that maintenance delays were caused by a lack of locally available components, while a global shortage of engines for Airbus A320neo planes led to the grounding of 350 aircraft worldwide, including those in its fleet. This was due to financial constraints, government procurement procedures, lack of technical automation, and similar constraints imposed by the company (Sri Lankan Airlines Annual Report 2019/2020). Furthermore, passenger-related problems such as late arrivals and baggage handling issues were seen that caused dilution of the company goodwill & reputation. In addition to that, technical

crew shortages also affect flight schedules, which will lead to service interruptions and operational failures in the aviation industry (Lahiru Doloswala 2023).

Despite the limitations of traditional systems, Sri Lankan Airlines recognizes the potential of machine learning to mitigate the adverse effects of flight delays. As evidenced by the Sri Lanka Airlines Annual Report 2019/2020, the airline has actively explored machine learning, big data, and predictive analytics through collaborations with university researchers to develop innovative solutions.

A. Overview of Machine Learning (ML)

Machine Learning (ML) is a subset of Artificial Intelligence (AI) that enables computers and devices to give solutions, including image recognition, natural language processing, speech recognition, and other predictive analytics techniques. As per the investigation, the following are the prevalent ML models used to predict flight delays. CatBoost, XGBoost, LightGBM, random forests, and deep learning models such as multi-layer perceptron (MLP), neural networks, and regression models. Generally, these algorithms have predictable capabilities based on past information. Moreover, a large set of past information increases the efficiency of algorithms in predictions. (u et al.). These algorithms were utilized by specialized architectures designed for specific applications with forecasting facilities named Air Aware. (Meshal Alfarhood et.al 2024).

The following figures 1 and 2 show the functions of the Air Aware application.

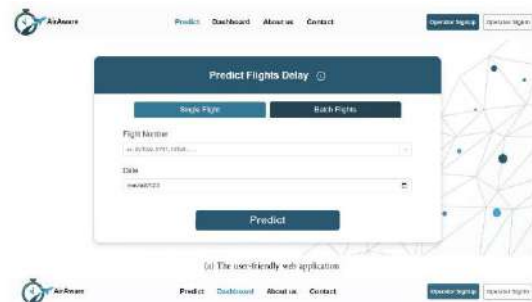


Figure 1 Air Aware Application



Figure 2 The dashboard of Air Aware Application

ML adaptation in airlines has made a significant contribution to seeing the probability of flight delays by leveraging historical data and features such as the aircraft type, arrival and departure time, tail number, flight number, origin, destination ports, etc. The literature has proven the potential of ML technology in achieving promising outcomes. Therefore, verifying its acceptance level is fundamental.

Alharbi and Prince employed ML techniques to predict flight delays with three algorithms named logistic regression, decision tree, and multilayer perceptron (MLP). To measure each accuracy level of predictions, they utilized data from the General Authority of Civil Aviation (GACA) in Saudi Arabia and the Kaggle dataset. As the result of their study, they achieved the highest accuracy level in MLP as 0.8957 for the data from GACA and 0.9843 for the Kaggle dataset.

Tang utilized seven ML algorithms from flight datasets in a year consisting of JFK Airport. According to his study, the decision tree obtained a 97% accuracy rate, the highest among other algorithms. The researchers believe the dataset from multiple years would further validate the ML model's prediction capabilities in flight delays.

Several researchers have used these algorithms to predict delay statistics. Neural networks, one of the ML algorithms were used in research conducted by Sridhar, et al., to predict flight delays in airports by leveraging patterns of weather conditions. Flight schedules were interrupted by weather conditions indicating high wind, heavy rain, and low visibility (Allan et al 2001). Furthermore, the study carried out by Rebollo and Balakrishnan identified that air traffic influences flight delays in airlines. They adopted regression and random forest models to explore prediction for delays caused by air traffic. The analysis was conducted with selected algorithms across the 100 links frequently delayed within National Air Space (NAS) in America. The result showed that the prediction error was less than 19%, presenting a good performance of adopted algorithms. Airport congestion is also a factor contributing to flight delays. Kwan and M. Hansen (2011) stated that 32% of flight delays occur due to airport congestion which resulted from an econometric analysis conducted by them. Lack of maintenance requirements for aircraft disrupts passenger convenience and flight schedules. Yan et al. (2017) used random forest ML algorithms to detect high-priority defects earlier to optimize maintenance execution.

Machine learning is a promising tool to achieve passenger satisfaction and cost efficiency in flight operations in the Sri Lankan aviation industry. According to the study by Deshpande and Arkan (2012), flight delays generated 31 billion USD of additional costs for air operations, which simultaneously impacted passenger satisfaction as well. C. Y. Yiu et al., (2021) also illustrated that continuous occurrences of flight delays would be

detrimental to operation efficiency and company goodwill. The research conducted by Maswood Alam et al. proposed machine learning algorithms to mitigate the repercussions of flight delays and to provide valuable insight for all aviation stakeholders, potentially improving cost efficiency and overall travel experiences.

In airline industry operations, benefit management is a crucial aspect. Benefit management is the process of planning, organizing, and monitoring the benefits emerging from the airline and the company. The process involves benefit identification, realization planning, monitoring of benefits, and benefit realization as overall factors (Ward et al. 1996). The study focuses on benefit identification with a special focus on intangible outcomes. This also leads to the benefit measurement, which is done through fuzzy logic inference (Deshpande,1960). The benefits of this industry are two types, namely, immediate targets and long-term outcomes. Immediate targets are process efficiency, long-term cost savings, and passenger satisfaction.

B. Leveraging fuzzy inference system in flight delay mitigation

As the conceptual framework explains, air traffic has a major impact on flight schedule punctuality. Some works involve the use of fuzzy logic as a mechanism to support decision-making in different problems related to air traffic control, such as the exchange of flight levels and speed control (Lovato et al., 2006, Lovato and Oliveira, 2010), take-off and landing (Lima, Fontes, & Schnitman, 2010), and setting flight routes (Shafahi et al., 2010, Sun et al., 2015). Stula, Stipanicev, and Bodrozic (2010) combine a multi-agent approach with fuzzy cognitive maps to support decisions in air traffic control. Aircraft maintenance is like a regular checkup for a plane, ensuring it's safe to fly and avoiding delays. But it can be expensive, taking up about 9% of an airline's yearly costs (Qin et al., 2018). A clever idea to make maintenance more efficient and save money is to use Fuzzy inference Systems (FIS). Like a detective, FIS can spot problems in aircraft engines, helping us make smarter decisions and fix things faster.

C. Operationalization

Independent variables	Dimensions	Author	Journal title	Remarks
Extreme Weather conditions	Rainy	Allan et al. (2001)	Effect of airline choice and temporality on flight delays	Emphasized that different weather conditions can cause flight delays.
	Wind speed	Allan et al. (2001)		
	Visibility	Allan et al. (2001)		
Aircraft Maintenance issues	Technical Faults	Nuttall, (2024)	SriLankan Airlines CEO addresses flight delay concerns, highlights industry challenges	Emphasized technical errors and lack of procuring of spare parts as key causes for flight delays.
	Spare parts unavailability	Nuttall, (2024)		
	Unavailability	Lalitha De Silva, (2023)	Why Is Sri Lankan Airlines Facing Flight Cancellations and Technical Crew Shortages?	Emphasized to prioritize the technical crew staffing for future flight departures.
	Maintenance crew	Lalitha De Silva, (2023)		
Airport Congestions	Queue in ticketing and visa process	Kwan, et. Al (2011)	U.S. Flight Delay in the 2000s: An Econometric Analysis	Highlighted airport congestion and queuing delays as adverse consequences of flight disruptions
	Delays at checkpoints	Kwan, et. Al (2011)		
	Employee strikes	Kwan, et. Al (2011)		
Air traffic	Air traffic control center	Wang, Jintao et al. (2024)	A resource prediction method for air traffic cyber-physical-social system	How air traffic congestion contributes to flight disruptions.
Dependent variable				
Machine learning enables with prediction of Flight delays		Zameir, Mironville, Mironville, Mironville (2023)	Flight Delay Prediction Using Machine Learning: A Comparative Study of Ensemble Techniques	Highlighted the potential of ML as a predictive mechanism to prevent flight delays and air operational inefficiencies.

III. METHODOLOGY

This section illustrates the framework that was implemented to measure the intangible deliverables of this study. The fuzzy logic is the model used in this research to achieve its objectives. The purpose of applying fuzzy logic is to quantify qualitative benefits in the industry (Dwivedi,2013). Fuzzy logic has three stages, namely input/ fuzzification, process/fuzzy inference system, and output/defuzzification. The following are the variables of the fuzzy logic approach: Very Late, Late, Moderately Late, and Cancelled. The reason to utilize the fuzzy method as a resolution for this research is to measure the intangible outcomes of long-term cost savings and customer satisfaction. This method is more hidden in past literature and is the best method, of analysing and identifying qualitative aspects rather than using models named 360 management practices, balanced scorecards, HR performance practices, and performance evaluation methods which are more oriented towards the quantitative measurable aspects. Therefore, this study focuses more on qualitative and uncountable variables and gives support to see the level to which the variables are achieved. With the use of this method, where the airline should adopt ML applications in conjunction with the fuzzy inference system, the Conceptual Framework can be identified.

The following table shows the independent variables, dependent variables, and dimensions of the study.

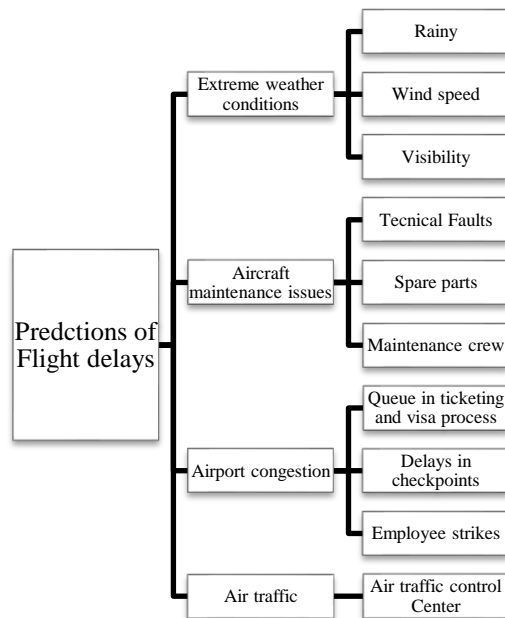


Figure 3 The conceptual Framework

Source: Developed by the Authors Based on the
Review of Literature (2024)

The dependent variable is the flight delay, and several reasons for flight delays are realized as independent variables, which are extreme weather conditions, aircraft maintenance issues, airport congestion, and air traffic. Extreme weather conditions impact flight schedules adversely due to factors such as strong wind, heavy rain, and low visibility. An ML-powered application could predict these conditions by analyzing data on weather situations. This predictive analysis enables airlines to manage their schedules and inform passengers of their potential delays well in advance and that would increase the overall travel experience.

Aircraft maintenance issues are the second independent variable. The aircraft engineers are unable to permit the takeoff of the aircraft before completing the required maintenance procedures. This process would be hindered by limitations in procuring facilities and local spare parts manufacturing capabilities. In addition to that the procurement procedures of engines for aircraft required a set of licenses. Much time is consumed for that. Therefore, maintenance could be delayed due to the absence of spare parts. As a resolution, ML-based online applications can be used to detect which aircraft has potential delays and which does not by evaluating the maintenance information. That allows airlines to decide what aircraft to replace and what aircraft needs further maintenance. This leads to the productivity of assets while optimizing the maintenance operations in the airlines.

Airport congestion also leads to delays in flight schedules. Airport congestion can be generated as a result of employee strikes, blockages in checkpoints, long queues for ticketing visa processes, etc. These impacts can be minimized with the usage of ML-powered applications since they have a predictive capability by gathering data regarding the above issues and that, provide the ability to take proactive measures to minimize the passenger inconvenience and operation repercussions.

Air traffic is the fourth variable that could affect flight delays. The air traffic is maintained and controlled by air traffic control (ATC) centers. They ensure safe and efficient air traffic operations. ML algorithms can be beneficial for air traffic management by analyzing data from ATC centers. This will be an advantage for airlines' flight schedule optimization and reduce passenger dissatisfaction with services. fuzzy logic inference system improves the predictive horizon of the fault detection system

IV. THE DISCUSSION AND FINDINGS

The formulation of conceptual frameworks leads to the identification of key factors affecting the situation.

The fuzzy inference system assists in the benefits realization, which provides valuable insights for the decision-making process by enhancing operational efficiency and overall customer experience in the aviation industry.

The following table shows the fuzzy logic interpretation and theorist analysis of variables in the aviation industry in Sri Lanka.

Table 1. Fuzzy interpretation for spare parts availability and availability of maintenance crew

No	Variables	Scale	Variables	Scale	Flight Schedule Status
1	Availability of the Spare parts	Low	Availability of the maintenance crew	Low	Cancellation
2	Availability of the Spare parts	Moderate	Availability of the maintenance crew	Low	Late
3	Availability of the Spare parts	High	Availability of the maintenance crew	Low	Moderate Late
4	Availability of the Spare parts	Low	Availability of the maintenance crew	Moderate	Late
5	Availability of the Spare parts	Moderate	Availability of the maintenance crew	Moderate	Moderate late
6	Availability of the Spare parts	high	Availability of the maintenance crew	Moderate	Moderate late
7	Availability of the Spare parts	Low	Availability of the maintenance crew	High	Very Late
8	Availability of the Spare parts	Moderate	Availability of the maintenance crew	High	late
9	Availability of the Spare parts	High	Availability of the maintenance crew	High	On-time performance

Based on the analysis of spare parts and maintenance crew availability, it can be concluded that flight schedules are most likely to operate on time when both resources are readily available. However, shortages in either spare parts or maintenance crew can lead to flight delays, with the severity of the delay increasing as the availability of these resources decreases. Flight cancellations may occur in extreme cases where both spare parts and maintenance crew are unavailable.

A. Fuzzy Implications on Detecting Flight Delays.

On-time performance, late, very late, moderately late, and cancelled are linguistic variables of flight schedule as shown by the above-mentioned fuzzy interpretations. This facilitates an improved decision-making process while achieving customer satisfaction and cost efficiency in airlines. Case No 1 exemplifies flight schedules with the classifications as very late, late, moderately late, and cancelled. This status exhibits the potential disruption in airline operations and passenger inconveniences. In such cases as delayed or cancelled flight status, the association with ML-powered applications in airline operations will be quite helpful by allowing stakeholders to forecast flight status accurately and take proactive measures to minimize the adverse repercussions of flight delays.

V. CONCLUSION

ML applications for predicting flight delays are a novel phenomenon. However, it is a post-modern aspect with the inclusion of a fuzzy inference system. The flight statuses pertaining to cancellations, delays, etc. can be detected from a fuzzy approach and

thereby determine where the airline should adopt ML applications to detect flight delays. The study implications are practically beneficial for Sri Lanka to augment customer satisfaction of passengers and increase cost savings.

VI. FURTHER RESEARCH

Technical analysis of AI and ML-powered applications in operations of the aviation industry in Sri Lanka.

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Analysis, prediction, and evaluation of Hendra virus transmission dynamics using machine learning algorithms

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Abstract— This work examines the dynamics of Hendra virus transmission using machine learning techniques, with particular attention to virus prevalence in Australia's New South Wales (NSW) and Queensland (QLD). Through the use of techniques like Random Forest, k-Nearest Neighbors (KNN), Logistic Regression, and Decision Trees on data spanning from 2011 to 2014, we discovered that there was a notable variation in the prevalence of the virus across different regions. Notably, Boonah, QLD, demonstrated a much higher detection rate of 8.4%. The results point to the need for surveillance and intervention plans tailored to each region. With Random Forest exhibiting the greatest ROC score of 83.24%, the models yielded an average accuracy of 95.8%. These findings offer vital information for public health planning and initiatives meant to slow the virus's spread in high-risk regions.

Keywords— Hendra virus, Transmission dynamics, Machine learning, Disease modelling, Virus prevalence, epidemiology, public health, Queensland, New South Wales

I. INTRODUCTION

Particularly in eastern Australia, the Hendra virus (HeV) is a zoonotic disease that presents serious hazards to the health of humans and animals. The virus was first discovered in 1994 and mostly affects horses. It can occasionally spread to people through intimate contact with sick animals, and the results are frequently lethal. The primary natural reservoirs of the virus, which aid in its spread throughout regions of Queensland (QLD) and New South Wales (NSW),

are flying foxes (*Pteropus* spp.) (Plowright et al., 2017; Johnson et al., 2015), which include the black flying fox (*Pteropus Alecto*) and the spectacled flying fox (*Pteropus conspicillatus*) (Field et al., 2015; Plowright et al., 2015).

Understanding the ecological and epidemiological aspects of HeV spread has been the focus of recent research efforts. The population dynamics of flying foxes, climate variability, and habitat degradation have all been found to be important factors in the spread of viruses. There are still gaps in our understanding of the whole relationship between these environmental elements and the patterns of viral transmission throughout time and place (Smith et al., 2014; Field et al., 2016). Even with these developments, data-driven strategies that incorporate these factors are still required to offer useful insights into the dynamics of HeV transmission.

By using machine learning approaches to examine virus transmission patterns, this study seeks to close this gap. This research provides a quantitative examination of HeV spread across important locations in NSW and QLD by using algorithms like Random Forest, k-Nearest Neighbors (KNN), Logistic Regression, and Decision Trees on historical data from 2011 to 2014. Potential virus hotspots can be identified using machine learning algorithms; Boonah, Queensland, has shown to have significantly greater detection rates than other regions (Smith et al., 2014; Field et al., 2016).

HeV ecology and epidemiology have been fundamentally understood by earlier research, but

many of these studies lacked a thorough, predictive model that took into consideration both population dynamics and environmental conditions. This study increases our understanding of HeV transmission and gives public health officials the tools they need to create focused intervention plans, reducing the likelihood of future outbreaks. It does this by employing a data-driven, predictive methodology.

II. LITERATURE REVIEW

It has long been known that the Hendra virus (HeV) poses a serious zoonotic hazard, especially in eastern Australia, where interactions between flying foxes (*Pteropus* spp.) and other animals, such as horses and people, are the main factor driving the virus's transmission dynamics. Previous research has confirmed that flying foxes serve as natural reservoirs for HeV. Notable vectors of the virus include the spectacled flying fox (*Pteropus conspicillatus*) and the black flying fox (*Pteropus Alecto*) (Field et al., 2016; Plowright et al., 2015). The intricate ecological and epidemiological linkages that affect the virus's propagation are highlighted by this research.

D. Hendra Virus Ecology and Epidemiology

Environmental changes like habitat loss, changes in land use, and climate variability are among the key variables impacting the transmission of the virus, according to research on the ecology and epidemiology of HeV. Field and colleagues (2015) discovered, for instance, that disturbances in flying fox habitats brought on by urbanization and deforestation can greatly raise the probability of spillover events. Furthermore, Plowright et al. (2015) highlighted how reproductive practices and nutritional stress shape the risk of transmission, especially when flying fox populations are under ecological stress.

Studies have shown how crucial it is to comprehend the time and spatial dimensions of HeV transmission. After completing a thorough spatial investigation of flying fox populations and HeV prevalence, Smith et al. (2014) came to the conclusion that mobility patterns and population density are important factors in the spread of the virus. According to their findings, areas like Queensland (QLD) that have high flying fox concentrations are more vulnerable to spillover events, which calls for the development of region-specific surveillance and intervention plans.

E. HeV's Spatiotemporal Dynamics

Apart from the ecological aspects, a crucial field of research has been the spatiotemporal dynamics of HeV. According to Field et al. (2016), longitudinal datasets have shown notable seasonal and annual changes in virus detection. These results underline the necessity of continuous HeV surveillance in regions

like Queensland (QLD) and New South Wales (NSW) that have dense populations of flying foxes.

Despite advancements, a large body of current research still lacks comprehensive models capable of predicting the temporal and spatial spread of HeV by integrating ecological, environmental, and demographic aspects. Although research on population dynamics is highlighted by studies such as Smith et al. (2014), little is known about the ways in which variables such as climatic variability affect these dynamics. This emphasizes the necessity of developing more dependable, data-driven methods for predicting HeV transmission.

F. Machine Learning for Disease Modelling

Because machine learning can handle enormous datasets and intricate connections between variables, it has gained attention in recent years for use in epidemiological modeling (Xu et al., 2016; Brett et al., 2020). But applying machine learning to HeV research is still relatively new. Traditional epidemiological models, such as SIR (Susceptible-Infected-Recovered) models, have been the basis of most investigations. Although helpful, these models have limitations when it comes to integrating many factors that impact transmission (Plowright et al., 2015; Field et al., 2016).

By using machine learning techniques to forecast HeV transmission patterns, including random Forests, k-nearest neighbours (KNN), logistic regression, and decision trees, this study aims to overcome this constraint. These methods provide a more advanced way to examine the ways in which geographical variations, flying fox population density, and climatic variability influence the spread of HeV. This study fills in the gaps in prediction modelling while building on the basic work of Dynamics of Populations and the Spread of Viruses.

To examine the association between HeV transmission and flying fox population dynamics (such as migration patterns and density), assessing the role that demographic variables play in variations in virus prevalence throughout the research areas. Earlier studies used historical data from 2011 to 2014 (Smith et al., 2014; Field et al., 2016).

III. METHODOLOGY

Utilizing a quantitative research methodology, this work integrates machine learning algorithms to forecast and analyze the dynamics of Hendra virus (HeV) transmission throughout Queensland (QLD) and New South Wales (NSW), Australia. The study makes use of an extensive dataset covering the years 2011 through 2014 and focuses on the dynamics of

flying fox populations, environmental factors, and virus prevalence.

A. Data Gathering

The dataset utilized in this investigation was obtained from publicly accessible documents and papers, including estimates of the flying fox population in the area and findings from Polymerase Chain Reaction (PCR) tests for the Hendra virus. The data covers several Eastern Australian locations, but it focuses especially on QLD and NSW because those states have recorded Hendra virus epidemics. The prevalence of viruses, their geographic location, the number of flying foxes in the population, and environmental factors, including land use and climate, are important data points.

The dataset was heavily pre-processed to manage outliers and missing data before machine learning models were used. The necessary preprocessing was:

1. Data cleaning is the process of eliminating or imputing missing values for continuous variables using mean imputation techniques.
2. Z-scores are used in outlier detection in order to locate and handle outliers and preserve data integrity.
3. Feature engineering is the process of adding new features, including dividing temporal data into components related to the year and the season and figuring out the population density in each area.

B. Exploratory Data Analysis (EDA)

To find patterns, correlations, and trends in the dataset, exploratory data analysis, or EDA, was used. To understand the relationships between variables, EDA used both descriptive statistics and visual aids such as histograms, scatter plots, and correlation matrices.

1. Numerical Variables: Histograms and boxplots were used to analyze the distribution of viral prevalence, flying fox population size, and environmental parameters.
2. Categorical Variables: To examine the geographical distribution of viral detection and contrast regional prevalence, bar charts were employed.
3. Correlation Analysis: To determine the connections between viral prevalence, environmental factors, and population size, correlation matrices were constructed.

C. Machine Learning Model

The following four machine learning techniques were used to forecast the dynamics of the Hendra virus's transmission:

1. An ensemble learning technique called Random Forest is perfect for managing high-dimensional data and prioritizing features since it finds non-linear correlations and significant HeV transmission predictions.
2. KNN is a non-parametric technique that predicts HeV presence based on similar cases' proximity, making it effective in noisy datasets.
3. Logistic regression is a binary classification model that predicts virus transmission probability and offers valuable insights into transmission risk factors.
4. Decision Tree is a supervised learning technique that simplifies classification rules, aiding in understanding the impact of various factors on virus spread.

D. Model evaluation

The performance of the machine learning models was evaluated using a number of important criteria. The percentage of cases properly predicted was used to measure accuracy. Recall measured the model's capacity to identify real positives, whereas precision showed the ratio of true positives to all positive predictions. For unbalanced data, the F1-score—a harmonic mean of precision and recall—was employed. Finally, the model's capacity to discern between positive and negative examples was assessed using ROC-AUC.

E. Model Training and Testing

The dataset was split into training and testing sets, with 80% of the data used for training and 20% reserved for testing. Cross-validation was performed using a 5-fold approach to ensure that the model generalizes well to unseen data. Hyperparameters for each model were tuned using grid search to identify the optimal parameters for maximizing performance.

F. Interpretability of the Model

In order to determine which factors—such as flying fox population size, geographic location, and environmental variables—have the greatest influence on HeV transmission, feature importance rankings were produced using the Random Forest model. The decision rules that direct the categorization of viral transmission events were also made clear by decision tree representations.

This methodological approach provides a strong framework for comprehending how environmental and demographic factors contribute to virus propagation by integrating machine learning techniques to evaluate and predict the transmission dynamics of the Hendra virus. A thorough examination is made possible by the employment of many models, each of which offers a different

perspective on the variables influencing the spread of viruses.

IV. RESULT AND DISCUSSION

An essential resource for examining the prevalence of the Hendra virus in East Australia, specifically in Queensland (QLD) and New South Wales (NSW), between 2011 and 2014 is the Hendra Virus Prevalence and Geographic Analysis Dataset (HVPGAD). With 15, variables and 13,637 observations, it provides information on population estimates, viral prevalence trends, and geographical dynamics.

1) The influence of Hendra virus prevalence on test outcomes:

With 4.6% of samples testing positive and 95.4% negative, "Figure 1" illustrates the prevalence of Hendra virus through PCR test distribution. This regional variability highlights the significance of targeted interventions and surveillance; local contexts are essential for creating public health policies that are effective and customized strategies that manage Hendra virus infections.

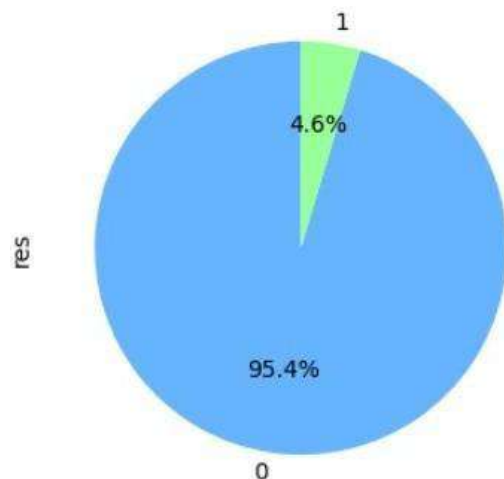


Figure 1. Percentages of Hendra Virus PCR Test Results

2) Assessing Hendra Virus Prevalence and Disparities in Australia through State-Based Analysis: "Figure 2" shows significant variations in virus prevalence based on a comparative study of Hendra virus test findings from different states. Particularly high detection rates in Queensland suggest that the

state may be at higher risk of contracting the virus. Comparatively speaking, New South Wales has fewer cases reported, which suggests a lower prevalence.

The considerable difference in detected cases between Queensland and New South Wales emphasizes the importance of customizing monitoring, prevention, and control methods to specific regions. This emphasizes the necessity for region-specific approaches to Hendra virus dynamics, considering ecological, meteorological, and geographical factors that contribute to observed disparities.

The increased number of reported cases in Queensland highlights the need for targeted surveillance, public awareness efforts, and preventive interventions in this area. Recognizing regional disparities is crucial for developing successful public health treatments that address the unique challenges given by varied virus frequency across different geographic regions.

These results help to clarify the spatial dynamics of the Hendra virus and provide guidance for the formulation of targeted and informed mitigation measures. To improve the efficacy of interventions targeted at reducing the impact of the Hendra virus in various geographic contexts, future research and public health activities should take these geographical variations into account.

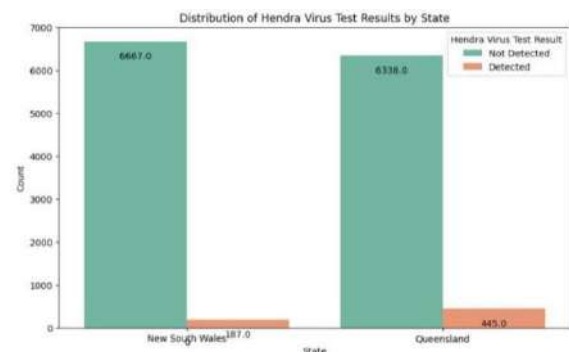


Figure 2. State-Level Analysis of Hendra Virus Detection

3) Hendra Virus Test Results and Average Flying-Fox Counts in East Australia:

The average number of flying foxes classified as "Detected" and "Not Detected" according to Hendra Virus testing is displayed in "Figure 3." The information points to a connection between flying fox populations and virus prevalence, highlighting the importance of taking population dynamics into account when managing animals and diagnosing viruses. Targeted efforts for wildlife and public health initiatives are informed by these findings.

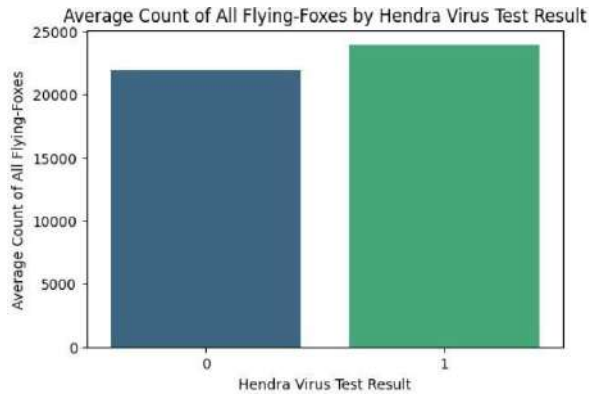


Figure 3. Average count of all flying foxes by test results

4) Hendra Virus Prevalence: A Geographical Analysis:

Significant regional variation was found when the incidence of viruses was analyzed in several Eastern Australian regions, especially in Queensland (QLD) and New South Wales (NSW). Boonah, Queensland, had a noticeably greater detection rate (8.4%) than the other localities, as seen in Figure 4. This implies that Boonah could be a potential hub for the spread of the Hendra virus. The necessity for region-specific public health measures is highlighted by the spatial variance in viral prevalence, especially in areas with greater detection rates.

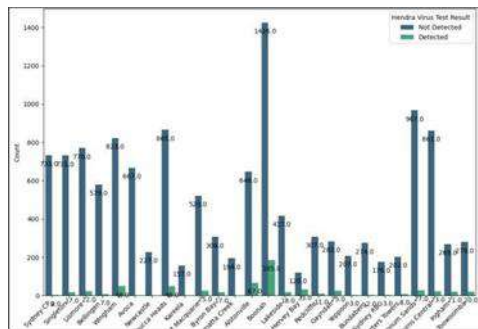


Figure 4: Location-based Analysis of Hendra Virus Prevalence

The findings of this geographic analysis emphasize the significance of customized surveillance programs in areas where the virus is more common, since this enables the development of more focused intervention plans.

5) Temporal Trends in the Spread of Viruses:

Notable changes were seen when the temporal dynamics of Hendra virus prevalence were analyzed from 2011 to 2014. Figure 5 shows that the mean prevalence of viruses peaked in 2011 at 0.18 and then significantly declined in 2012. The prevalence rates in the years that followed were variable but still modest.

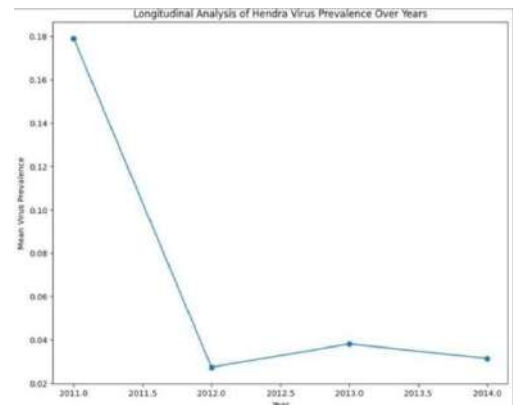


Figure 5: Longitudinal Analysis of Hendra Virus Prevalence (2011-2014).

These results highlight the significance of ongoing surveillance, especially in times of elevated viral prevalence. The 2011 peak might have been brought about by demographic or environmental factors that affected the spread of the virus at that time.

6) Performance of Machine Learning Models:

Based on their capacity to forecast the spread of the Hendra virus, the machine learning models employed in this investigation—Random Forest, k-Nearest Neighbors (KNN), Logistic Regression, and Decision Trees—were assessed. The performance metrics for every model are compiled in Table 1.

TABLE 1: COMPARISON OF MODEL PERFORMANCE (ACCURACY, PRECISION, RECALL, F1-SCORE, AND ROC-AUC).

Model	Accuracy	Precision	Recall	F1-Score	ROC-AUC
Random Forest	95.8%	0.96	0.95	0.95	83.24%
k-Nearest Neighbors	95.4%	0.95	0.94	0.94	71.25%
Logistic Regression	95.8%	0.96	0.95	0.95	77.56%
Decision Tree	95.8%	0.95	0.94	0.95	70.32%

With the highest ROC-AUC score of 83.24% and the highest accuracy of 95.8% among the models, Random Forest was the most successful. The efficacy of all models in forecasting the propagation of the Hendra virus is demonstrated by their remarkable accuracy. In contrast, Random Forest fared better than other models in differentiating between positive and negative cases of virus transmission, according to the ROC-AUC values.

7) Interpretation and Significance of Features:

In addition, the Random Forest model yielded feature relevance rankings that aided in determining the key variables influencing the likelihood of the Hendra virus spreading. The main characteristics that influenced the model's predictions are shown in Figure 6.

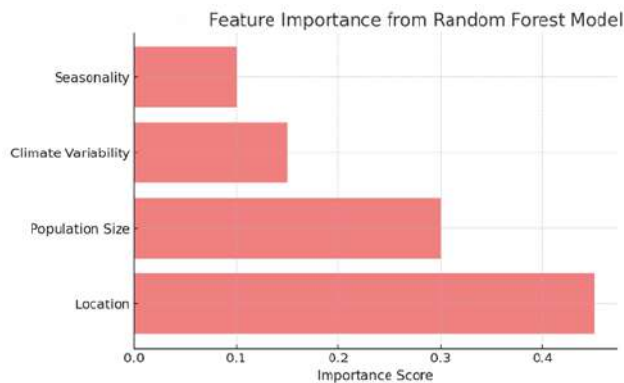


Figure 6: Feature Importance Ranking from the Random Forest Model.

8) Parameterized Predictions in SIR Model-Based Simulation:

The dynamics of the Hendra virus's propagation over a 160-day period were simulated using the SIR (Susceptible-Infected-Recovered) model (Kermack & McKendrick, 1927; Diekmann et al., 2013). Figure 7 displays the findings of the simulation, which show how the virus spreads among three major population groups: susceptible, infected, and recovered individuals.

1. Contact Rate (β): Based on data in high-risk areas such as Boonah, QLD, the rate at which vulnerable individuals come into contact with infected persons was parameterized.
2. Recovery Rate (γ): Based on clinical evidence, this indicates the rate of recovery for infected patients.

Figure 7 shows how the infected population climbs dramatically before peaking and then dropping as more people recover, whereas the vulnerable population steadily declines over time as the virus spreads. Throughout the course of the simulation, the recovered population grows gradually.

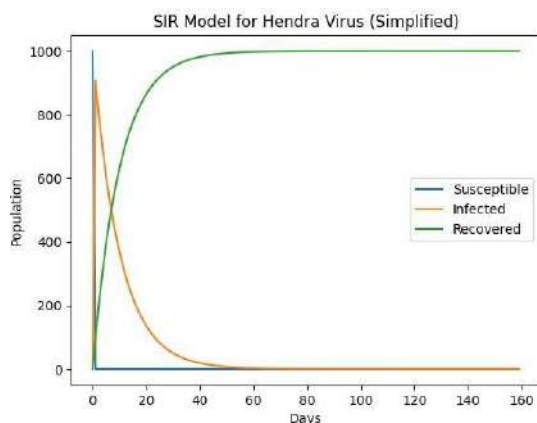


Figure 7: SIR Model Simulation of Hendra Virus Spread over a 160-day Period.

The simulation supports outbreak observations, showing rapid virus spread in high-prevalence areas can be contained with prompt treatments, quarantine, surveillance, and biosecurity measures.

The study's findings reveal Hendra virus transmission patterns, machine learning effectiveness, and Boonah's hotspot status, emphasizing local surveillance and intervention plans, especially during high prevalence periods like 2011.

Machine learning models showed promise in predicting the spread of viruses; Random Forest was especially effective in this regard. The models exhibit good accuracy and ROC-AUC values, indicating that machine learning may effectively manage the intricate dynamics of Hendra virus transmission, hence serving as a potent instrument for public health planning.

The practical ramifications of the study's findings are noteworthy for public health authorities. The design of focused surveillance programs, resource allocation, and intervention techniques can be aided by the identification of geographic hotspots and the application of predictive models. Public health workers can stop future outbreaks more successfully by concentrating on areas with higher viral prevalence and knowing the factors that contribute to those outbreaks.

VI. CONCLUSION

This study examines the spread of the Hendra virus in Eastern Australia using machine learning methods and a simulation based on the SIR model. Important hotspots, such as Boonah, Queensland, were located, and the prevalence of the virus was monitored over time, highlighting the necessity of focused public health initiatives. High accuracy was demonstrated by Random Forest models, where flying fox density and geographic location were the main predictors. The SIR-based simulation also demonstrated how prompt measures like surveillance and quarantine might stop the spread of viruses.

The study enhances predictive models by incorporating environmental and climatic factors, providing a data-driven approach for public health authorities in Hendra virus outbreak-prone regions.

Future research could enhance models by incorporating new data sources, using advanced machine learning methods, and adding variables like immunization and vector control to improve prediction capacity and enhance disease management tactics.

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IMPACT OF LONG-TERM SPORTS PARTICIPATION IN ATHLETIC RUNNING EVENTS AT SPORTS SCHOOLS IN SRI LANKA

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Abstract- This study aims to understand the impact of long-term sports participation on athletic performance and academic subject stream choices among athletes in sports schools in Sri Lanka. A descriptive survey design was applied, involving 50 advanced level athletes selected through total population sampling from each province based on their performance in recent years. The factors considered for long-term participation include education, sports, social background, family, injuries, and nutrition. Data were collected via a questionnaire and analyzed using SPSS software with ANOVA to determine the significance of the model. The results

showed that education background (0.008), sports background (0.015), and social background (0.032) significantly impact long-term participation. The majority of athletes (70%) opted for the Art stream, with 16% in Commerce and 14% in Technology. Performance levels indicated that 68% were national level athletes, 26% provincial, 4% district, and 2% zonal. These findings suggest the need for improved facilities and support for athletes to balance sports and academic pursuits. This study provides valuable insights into the factors influencing long-term participation in sports among advanced level athletes in Sri Lanka. The results emphasize the importance of

supporting athletes' educational and social needs to enhance their performance and sustain their involvement in sports. Improved facilities and targeted support can help balance the demands of sports and academics, contributing to the overall development of athletes.

Keywords

Advanced level athletes, Long-term participation, Performance, Sports school.

Introduction

Participation in sports is widely acknowledged for its numerous benefits, including improved physical health, mental well-being, and social skills. For young athletes in sports schools, balancing rigorous training schedules with academic responsibilities poses unique challenges. In Sri Lanka, sports schools play a pivotal role in nurturing athletic talent, particularly in running events, which have seen significant national and international achievements.

However, long-term engagement in sports can be influenced by various factors such as education, sports infrastructure, social environment, family support, injuries, and nutrition. Understanding how these factors impact athletes' sustained participation and performance levels is essential for developing comprehensive support systems.

Previous research has primarily focused on the physical and psychological benefits of sports participation, with less emphasis on the interplay between academic choices and athletic performance. In the Sri Lankan context, where education is highly valued, it is crucial to examine how athletes' academic stream choices influence their sports careers and vice versa.

In Sri Lanka there are huge numbers of students. Unfortunately lots of children enter the high school after the A/L exam and give up sports. That creates low youth retention for sports. But with the correct education, balance between education and performance can be taught. So this may help to identify the problems related to male students who are in the sports schools. And how is that's problems effect to their performance.

This study aims to fill this gap by exploring the impact of long-term sports participation on both athletic performance and academic subject stream choices among athletes in sports schools in Sri Lanka. By analyzing data from a sample of athletes following advanced level, this research seeks to provide insights into the factors that support or hinder prolonged involvement in sports, ultimately informing policy and practice to enhance the overall development of student-athletes.

The main Objective of this research is to understand the impact of long-term sports participation on athletic performance and academic subject stream choices among athletes in sports schools in Sri Lanka

In addition to the above objective, there are other three objectives of this research, such as

-To identify the performance level of athletes

-To identify which A/L stream is most student are used.

Methodology

1) Research study design

Researcher used descriptive survey design for this research.

2) Study area

Impact factors for long term sport participations in athletic running events of sport schools in Sri Lanka.

3) Population

All male and female athletes in sports school

4) Sample

50 Advanced Level Athletes

5) Sample Technique

Total population sampling technique

Data Collection Technique

Questionnaire

Data analysis

- Micros
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Results and Discussion

Table 01:Significance of Impact factors

Model	Significan
1 (Constant)	
Family 1	
Education 2	
Sport 3	
Social 4	
Injuries 5	

According to the above results, there are no significant differences in family background, social background and injury and nutrition. Because calculated P-values of these factors are higher than 0.05. The calculated p-value of educational background factor is 0.008 therefore this factor has significant difference, because the calculated p-value is less than 0.05. The calculated p-value of sport background factor is 0.015 therefore

this factor has significant difference, because the calculated p-value is less than 0.05. The calculated p-value of social background factor is 0.015

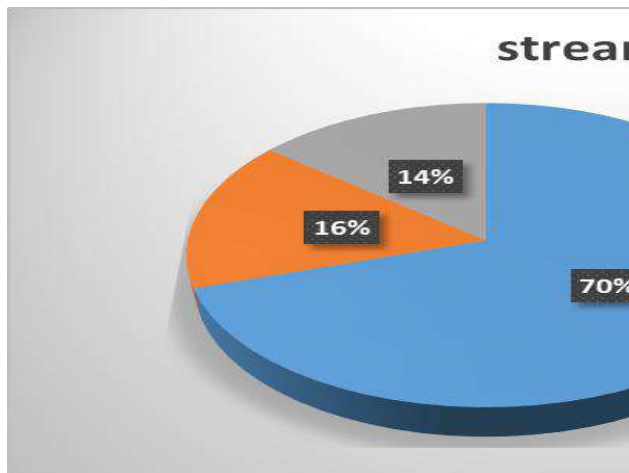


Figure 01 : A/L Subject stream

The pie chart reveals that the majority of athletes in sports schools prefer the Arts stream for their advanced level studies, with 70% choosing this path. Commerce and Technology streams are less popular among these athletes, with 16% and 14% of the athletes, respectively, enrolled in these streams. This distribution suggests that there might be a correlation between the nature of the Arts stream and the flexibility or support it offers to student-athletes in balancing their academic and athletic commitments.

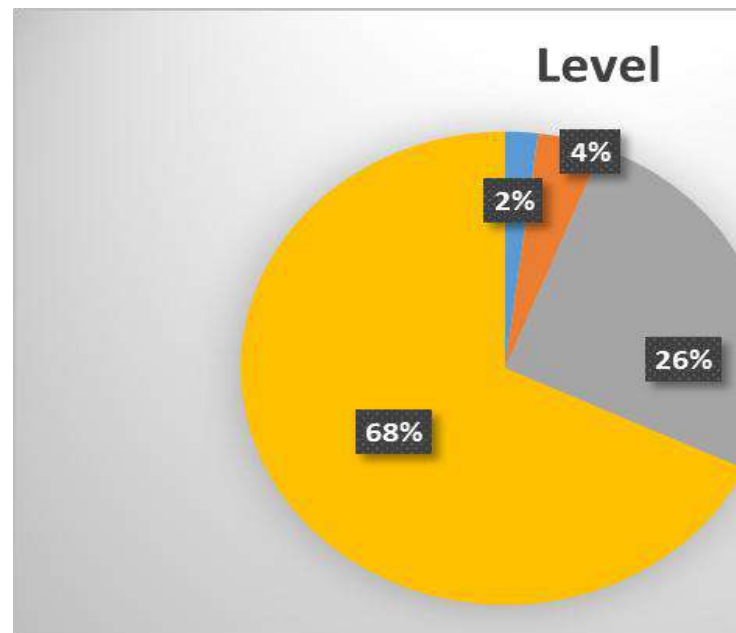


Figure 02 : Athletes Performance level

The pie chart reveals that a substantial majority of athletes (68%) are competing at the national level, demonstrating high performance and success in their athletic pursuits. The provincial level also has a significant representation with 26% of the athletes. In contrast, fewer athletes are competing at the district (4%) and zonal (2%) levels. This distribution suggests that sports schools in Sri Lanka are effective in nurturing athletes to reach higher levels of competition, with most athletes achieving national recognition.

Conclusion

This study examined the impact of long term participation in athletic running events of sports schools in Sri Lanka

The study sample was selected based on athlete's higher performance in the last year including each province in Sri Lanka. Data were collected through questionnaire survey among 50 athletes from advanced level students in sport schools.

Descriptive survey design was applied to this study. The study population is all the sports school athletes in Sri Lanka. From that 50 athletes were selected as study sample.

Education, sport, and social backgrounds are effect for the prolong athlete participation according to the final result, most effect factor for prolong athlete participation is educational background.

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The Impact of Teaching Speaking as a Skill for Grade 3 English as a Second Language Learners in Sri Lanka

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Abstract— English, as a global lingua franca, is crucial for communication, education, and professional growth. In Sri Lanka, English is taught as a Second Language (ESL) from early primary education, emphasizing its importance for students' academic and future career prospects. This study investigates the impact and effectiveness of teaching speaking skills to Grade 3 ESL learners in Sri Lanka, focusing on how instructional strategies influence speaking proficiency and overall language development. Speaking is a fundamental skill that enhances cognitive abilities, social interactions, and self-confidence among young learners. The research aims to identify the impact of teaching speaking on students' speaking strategies and evaluate the overall effectiveness of these instructional practices. The study involved 10 Grade 3 ESL students from St. Francis College, Dalugama, using a mixed-method approach that included pre-tests, instructional

sessions based on the "talk as transaction" theory, and post-tests. Findings indicate significant improvements in speaking proficiency, including reduced use of fillers, fewer requests for clarification, decreased reliance on mimes, and increased use of paraphrasing. These results suggest that targeted interventions and structured teaching methodologies, such as role-playing and interactive activities, can enhance speaking abilities, leading to greater confidence and fluency. The study underscores the need for continuous assessment and adaptation of teaching methods to meet diverse learner needs. However, it also highlights limitations due to the small sample size and suggests future research should involve larger, more diverse groups to provide a comprehensive understanding of effective ESL speaking instruction.

Keywords—Confidence, English as a Second Language, Sri Lanka, Teaching Speaking as a Skill

I. INTRODUCTION

As a global lingua franca, English plays a pivotal role in communication, education, and professional development worldwide. In Sri Lanka, where English is taught as a second language (ESL), proficiency in speaking English is particularly important for students' academic and future career prospects. Therefore, the primary education system in Sri Lanka places significant emphasis on developing English language skills among young learners. However, the effectiveness of teaching speaking skills in ESL classrooms, especially for Grade 3 students, requires a thorough examination to ensure that instructional strategies aligned with learners' needs and contribute to their overall language development. This study focuses on investigating the impact and effectiveness of teaching speaking as a skill to Grade 3 ESL learners in Sri Lanka. Grade 3 represents a critical stage in a child's education, where foundational language skills are solidified, and the ability to communicate effectively in English can greatly influence subsequent learning experiences. Speaking, as an active and interactive skill, not only aids in the practical use of language but also enhances cognitive abilities, social interactions, and self-confidence among young learners. The primary objectives of this research are twofold. Firstly, it aims to identify the impact of teaching speaking as a skill on the speaking strategies of students in a Grade 3 English as a Second Language (ESL) classroom in Sri Lanka. Secondly, the research intends to evaluate the overall effectiveness of teaching speaking as a skill in this context. This research seeks to answer two critical questions regarding the instruction of speaking skills in Grade 3 ESL classrooms in Sri Lanka; [1] To what extent does teaching speaking as a skill improve the speaking strategies of students? [2] How effective is teaching speaking as a skill in the Grade 3 ESL classroom in Sri Lanka? By addressing these questions, the research aims to provide a comprehensive understanding of the benefits and challenges associated with teaching speaking as a skill in early ESL education.

II. LITERATURE REVIEW

Johnson (1996) describes speaking as a combinatorial skill involving various things simultaneously. It is not merely about uttering words but involves a complex interplay of linguistic, cognitive, and social skills. The necessity of mastering this skill is underscored by several scholars who emphasize the fundamental

role of speaking in language acquisition and education. Seefa (2017) posits that the ultimate goal of learning a language should be to enable learners to speak that language. This perspective aligns with the pragmatic view that language education should prioritize communicative competence. Burns (2019) echoes this sentiment by stressing the vital importance of teaching and learning speaking in any language education classroom. According to Burns(2019), speaking should not only be an activity that occurs in the classroom but should be systematically and explicitly taught. Burns critiques the prevalent approach in many classrooms where speaking activities are often conducted without a structured pedagogical framework, leading to what she describes as 'doing speaking' rather than 'teaching speaking'. Graham-Mar (2004) provides a foundational rationale for focusing on speaking skills instruction, noting that language acquisition in humans begins with speaking and listening long before reading and writing. This developmental perspective suggests that speaking is the most natural and primary form of language use, thereby justifying its central role in language education. The significance of speaking skills in language proficiency is further highlighted by Brown and Yule (1983), who argue that many language learners consider speaking abilities to be the benchmark for language proficiency. They define fluency as more than just the ability to read, write, or understand spoken language; it is the capacity to communicate effectively with others.

The importance of teaching speaking within the context of second language acquisition cannot be overstated. Scholars emphasize that developing speaking skills is a fundamental component of language education, necessary for achieving fluency, accuracy, and communicative competence. Burns (2019) highlights that learning to speak in a second language involves enhancing the ability to use various linguistic components to produce spoken language fluently, accurately, and in a socially appropriate manner. This process must occur within the constraints of the speaker's cognitive processing capabilities. Burns' perspective underscores the complexity of speaking as it involves not just linguistic proficiency but also the ability to navigate social contexts and cognitive demands effectively. Kayi (2006) asserts that teaching speaking is a crucial part of learning a second language. Effective instruction in speaking skills enables students to become successful communicators. The necessity for a dedicated focus on teaching speaking is further supported by Dilini and Prahalathan (2021), who states, "Language teachers must pay adequate

attention to the teaching of speaking” (p. 64). This assertion highlights the need for intentional and systematic instructional practices to develop speaking skills. Dilini and Prahalathan's (2021) emphasis on "adequate attention" suggests that current practices may often be insufficient, pointing to a potential gap in language education where speaking skills are concerned

The demand for proficiency in the English language in Sri Lanka is driven by its significant impact on career opportunities and quality of life. Shashikala (2018) underscores that English proficiency increases one's chances of securing better employment and enhancing life prospects. This demand affects nearly every aspect of human existence and future goals in Sri Lanka, highlighting the importance of effective English language education. Despite the high demand for English proficiency, there is a notable gap between students' abilities to read and write in English and their speaking proficiency. Karunaratne (2003) and Perera (2001) attribute this discrepancy to a mismatch between English teaching materials and the style of instruction. The education system in Sri Lanka comprises three main levels: primary, secondary, and tertiary education, with state education being the predominant mode. The Ministry of Education (MoE) oversees state primary and secondary education (Indrarathne et al., 2022). English is taught as a core subject from Grades 3 to 11, while students in Grades 1 and 2 are exposed to an Activity-based Oral English program (Aloysius, 2015). Formal, textbook-based English language teaching begins at Grade 3, focusing on developing the four language skills: listening, speaking, reading, and writing. The syllabus for Grades 3 to 5 aims to lay the foundation for effective communication in English, enrich students' participation in primary school through enjoyable foreign language learning experiences, and develop positive attitudes towards further learning in secondary school. It also aims to build students' confidence in their ability to succeed in learning the language, support the acquisition of basic competencies related to the National Education Policy, and provide sufficient command of English for real-life situations (National Institute of Education, 2000, as cited in Little et al., 2019). Despite these comprehensive aims, Little et al. (2019) note that the syllabus is organized around the four skills but lacks clear guidelines on the allocation of time for each skill. Moreover, the teacher's guide places a stronger emphasis on reading and writing, which seems to contradict the curriculum's objective of balanced skill development. This imbalance may contribute to the observed gap in speaking proficiency among students. To address these issues, a more balanced approach to

teaching the four skills is necessary, with particular attention to enhancing speaking abilities. Despite the recognized importance of speaking skills, there is a noticeable gap in research concerning the specific methodologies and their effectiveness in the context of Sri Lankan primary education. This study aims to bridge this gap by evaluating learners' progress and identifying the effectiveness of teaching speaking as a skill for grade 3 ESL learners in Sri Lanka.

III. METHODOLOGY

Data for the study were collected using a random sampling technique, randomly selecting 10 Grade 3 ESL students from St. Francis College, Dalugama, Sri Lanka. Grade 3 was selected as the experimental group since the National Education Commission in a recent study state that English is taught formally as a subject from Grade 3 onwards (Premarathne et al., 2016). In addition, the notion of Critical Period Hypothesis for language acquisition suggests that neurocognitive changes in the brain during maturation influence language learning. Hence, the study was conducted through four stages selecting grade 3 ESL learners.

It began with a pre-test to assess participants' baseline speaking proficiency and the use of four speaking strategies. In the second stage, instructional sessions based on the “talk as transaction” theory (Richards, 2008) were conducted, involving interactive activities and small group discussions to provide practical experience in using speaking strategies. A post-test identical to the pretest was administered on the final day to measure improvements in speaking proficiency and strategy use.

A mixed-method approach, incorporating both quantitative and qualitative analysis, was utilized. The collected Data were evaluated using the criteria proposed by Douglas (2007). The quantitative data were analyzed manually while coding the frequency and accuracy of each strategy. The findings were presented in two charts: one representing pre-test results and the other representing the post-test results. Pre and post-test results were compared to measure the effectiveness of the instructional sessions. The qualitative data underwent comparative analysis using Douglas's (2007) criteria to identify patterns and common themes.

G. Analysis of data

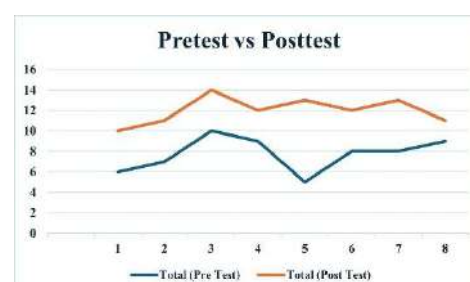


Figure 1. Pre-test vs. Post-test Data Analysis

IV. FINDINGS AND DISCUSSION

The findings of the study are presented under 4 themes and are discussed according to the two research questions.

A. Using fillers

Unlike in the pretest where extensive use of fillers was identified, posttest assessments show promising progress among the learners. In particular, there has been a noticeable reduction in the use of fillers, such as "um", "aaa" and "uh" which according to Wardani (2022) are employed to postpone the next unit that is due or aid a speaker in remembering the words they intend to say next. Such reduction indicates the impact and effectiveness of teaching speaking as a skill in terms of fluency and confidence in speaking ESL.

B. Asking for clarifications

The findings of the study also reveal that there is a reduction in asking for clarifications after the intervention. Such a decrease in instances of asking for clarification suggests that teaching speaking as a skill impact speaking strategies where students become more adept at expressing themselves clearly and effectively. Such development in fluency is crucial for effective communication in ESL.

C. Use of mime to convey meanings

Another positive outcome is the reduced reliance on mimes to convey meanings. This indicates the impact and effectiveness of teaching speaking as a skill where students become more proficient in verbal communication improving the ability to articulate thoughts and ideas using words rather than gestures. This finding is an indicator for language practitioners that guided practice and feedback makes students learn to construct sentences, engage in meaningful conversations, and convey information effectively, all of which contribute to a gradual decrease in the dependence on non-verbal cues like mimes resulting in improved linguistic abilities, enhanced confidence, fluency, and communicative competence among students.

D. Using paraphrases for structures one can't produce

The study also highlights the learners' increased use of paraphrases for structures they may find challenging to produce, which is indicated by the significant difference in the pre and post-tests. This demonstrates a willingness to experiment with different ways of expressing themselves and an enhanced understanding of the English language and pragmatics where an awareness of context, audience, and communicative intent are crucial aspects of effective spoken communication.

V. CONCLUSION

To conclude, this study highlights the importance of implementing a controlled and systematic approach to teaching speaking skills to grade 03 ESL learners in Sri Lanka. The findings demonstrate that utilizing targeted interventions and strategies, such as role-playing, interactive activities, and consistent feedback to practice transactional interactions, can significantly enhance learners' speaking abilities. This improvement in speaking skills leads to broader language development, fostering greater confidence and fluency in using ESL. The results suggest that a focused and structured teaching methodology, incorporating specific and well-planned activities, can positively impact students' speaking strategies, vocabulary acquisition, and overall language proficiency. Moreover, the study underscores the necessity of continuous assessment and adaptation of teaching methods to meet the diverse needs of learners.

A. Limitations and Further Study

The findings of the study should be interpreted with caution due to the limitations of examining a limited sample of learners, excluding proficiency levels and due to the external factors during sampling. Hence, future studies should consider involving a larger and more diverse group of participants, including students from different educational levels, cultural backgrounds, and geographical locations. To provide a more comprehensive understanding of the impact and effectiveness of teaching speaking as a skill in the ESL classroom, future research should utilize empirical studies on a larger and more diverse sample of learners, while also taking into account proficiency levels and external factors. In addition, student-centered perspectives with future studies should also prioritize understanding students' perspectives and experiences, including how it affects their motivation, engagement, and language acquisition. Addressing these suggestions can enhance the knowledge and practices surrounding teaching speaking in ESL settings. Further research in this area could explore additional techniques and approaches to enhance ESL learners' speaking skills. This would provide a more comprehensive understanding of effective strategies and contribute to advancing ESL education in diverse educational contexts.

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Predictive Modeling of Colombo Port Productivity Using Ship Movement Data.

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Abstract - Transportation plays a critical role in national development by impacting both integration within countries and their participation in the global economy. Within this sector, the maritime industry, particularly ports and terminals, is essential for facilitating international trade. This study examines the productivity of the Port of Colombo, a major transshipment hub on the main international shipping route. The port includes one state-owned terminal (Jaya Container Terminal) and two privately-owned terminals (South Asian Gateway Terminal and Colombo International Container Terminal), each differing in facilities and performance levels, thereby influencing shipping line demand. By analyzing 300 performance reports, this research investigates the effects of berth productivity, vessel productivity, and crane productivity on overall terminal performance. Data were processed and analyzed using Google Colab with methods including graphical interpretations, descriptive statistics, multivariate analysis, ANOVA tests, linear regression, and predictive modeling. The findings highlight that crane, berth, and vessel productivity significantly affect terminal performance, with crane scheduling and vessel turnaround time identified as critical factors. Notably, Colombo International Container Terminal (CICT) exhibited superior crane productivity compared to the other

terminals. These insights suggest strategies for optimizing terminal operations to enhance overall productivity.

Keywords: Port productivity, berth productivity, crane productivity, vessel productivity, regression models, waiting time, terminal performance.

1.0 Introduction.

Maritime and port activities are pivotal in the globalized economy, serving as critical nodes in the international supply chain. The Port of Colombo, a major transshipment hub on the Silk Route, plays a significant role in facilitating international trade through its three major container terminals: South Asian Gateway Terminal (SAGT), Colombo International Container Terminal (CICT), and Jaya Container Terminal (JCT). Efficient berthing, rapid cargo handling, and optimal crane usage are essential for maintaining competitiveness among these terminals. Despite operating within the same port, these terminals experience intense competition, which drives the need for continuous productivity improvements.

This study focuses on analyzing the productivity of the Port of Colombo's terminals by examining key performance

indicators such as berth productivity, crane productivity, and vessel productivity. The goal is to develop a predictive model that identifies the determinants of terminal productivity and explains the variations in performance across the terminals. This research contributes to the literature by providing insights into the factors that influence port productivity and offers practical recommendations for optimizing terminal operations (Hazen, B. T., Mollenkopf, D. A., & Wang, Y, 2017)

The structure of this thesis includes an introduction to the topic, a comprehensive review of empirical and theoretical literature, a detailed explanation of the research methodology, a presentation of the findings, and a conclusion with strategic recommendations for improving terminal productivity (Sharma, V. K., Sachdeva, A., & Singh, L. P., 2021)

2.0 Literature Review

2.1 Technical Productivity of Container Terminals

Productivity in maritime container terminals, as defined by Stephens (2012), is the output-to-input ratio that includes the efficient use of labor, assets, machinery, vessels, cargo handling equipment, and managerial entrepreneurship. This multifaceted definition underscores the importance of both tangible and intangible resources in optimizing terminal operations. Dowd (1990) and Ting (2011) further elaborate that terminal efficiency is shaped by internal factors, such as capital investment and labor productivity, and external factors, such as shipping patterns and landside capacities. While internal factors are directly controllable by terminal management, external factors require adaptive strategies to respond to market and logistical conditions.

Griffin (2006) and UNCTAD emphasize key operational indicators, such as tons per gang hour and turnaround time, which are critical for assessing terminal effectiveness. These metrics provide essential insights into the efficiency of cargo handling operations and vessel turnaround, both of which are vital for minimizing delays and maximizing throughput. However, as Esmer (2008) points out, challenges in data transparency and disclosure often hinder a comprehensive analysis of terminal productivity. Despite these challenges, core metrics like vessel, crane, quay, terminal, and equipment productivity remain essential for evaluating port terminal performance.

Despite these significant contributions, the literature lacks a focus on predictive modeling of terminal productivity specific to the context of Colombo Port. This study aims to fill this gap by applying advanced statistical techniques to analyze productivity determinants across different terminals, providing a more nuanced understanding of port operations and their optimization."

2.2 Empirical Background.

Crane, berth, ship turnaround, labor, vessel, gate, and yard productivity are critical technical factors that influence terminal selection by shipping lines, determining a terminal's operational efficiency and cost-effectiveness in a competitive maritime industry (Ilmer, 2003). Efficient crane productivity, measured by containers moved per crane per hour, directly impacts vessel turnaround times, while berth productivity, defined by the number of vessel calls a berth can handle, helps minimize congestion and optimize docking space. Reducing ship turnaround time through optimized berth allocation and crane operations enhances terminal productivity and service reliability. Labor productivity, improved through training and automation, significantly expedites cargo handling, reducing delays. Vessel productivity, influenced by smooth operations and advanced technologies like automated guided vehicles and gantry cranes, boosts efficiency in container handling. Gate and yard productivity, which manage truck turnaround and container organization, respectively, are essential for reducing congestion and enhancing supply chain efficiency. Overall, investing in advanced equipment and automation has been proven to minimize port times, reduce transshipment costs, and improve a terminal's competitiveness in the global shipping industry (Ilmer, 2003).

2.3 Research Questions

How do berth productivity, crane productivity, and Vessel productivity affect and what are the crucial factors determining such productivity of the three terminals JCT, SAGT, and CICT, and using those factors, create a predictive model.

2.3.1 Research Objectives

- Examine the inter-terminal technical productivity of the Port of Colombo from the perspective of shipping lines under identified productivity types.
- Analyze the berth productivity, crane productivity, and vessel productivity of each terminal separately.
- Identify the most productive terminal based on the productivity indicators.
- Evaluate any differences in productivity between the government-owned Container Terminal (JCT) and the privately-owned terminals (SAGT and CICT).

- Develop a prediction model for forecasting productivity.

3.0 Methodology

3.1 Data Collection Methods

The Port of Colombo, renowned as a "transshipment hub," comprises three major terminals JCT, CICT, and SAGT that play pivotal roles in maintaining its regional hub status. The primary data for this study primarily consisted of secondary sources, specifically monthly vessel schedule reports provided by terminal operators. These reports detail the scheduling of vessels, allowing shipping lines to prepare for operations. Once a vessel docks, it remains at the terminal until departure, engaging in cargo loading and unloading operations. After departure, terminal operators send performance reports to the respective shipping lines, forming the foundation of this study Agarwal, 2015.

3.2 Population and Sampling

This study employed a random non-probabilistic sampling method. Samples were obtained from major shipping lines JCT, SAGT, and CICT via detailed information gathered through direct communication. Due to time constraints, 300 vessel performance reports each were collected from JCT, SAGT, and CICT. According to Bairoju (2014), a minimum sample size of 30 or more is recommended for research Bairoju (2014), ensuring that the sample size in this study was adequate to achieve the research objectives.

3.3 Conceptual Framework

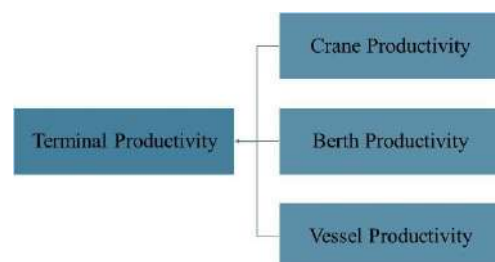


Figure 1 Conceptual Framework

3.4 Data Analysis Tools and Techniques

The research employed descriptive statistics, including central tendency measurements, graphs, and pie charts, for descriptive analysis. For statistical analysis and predictive modeling, ANOVA and Multiple Comparison methods under Post-Hoc Test were utilized. Data were input into an Excel sheet and analyzed using Google Colab.

3.4.1 Productivity Calculation Formulas

- $BP = \text{Total Moves} / \text{Berth Duration}$
- $CP = \text{Total Moves} / \text{Gross Crane Working Hours}$
- $VP = \text{Total Moves} / \text{Ship Turn Over Time}$
- $TP = (1/3 * BP) + (1/3 * CP) + (1/3 * VP)$

3.4.2 Normality Test

Parametric tests require normal data. Normality can be assessed visually and numerically (e.g., Shapiro-Wilk Test). The Central Limit Theorem states large samples (>30) tend towards normal distributions. Zahediasl (2012) supports this with sample sizes ≥ 30 . Despite vessel productivity's non-normality, the test was crucial. Results below show the Shapiro-Wilk Test outcomes; $p < 0.05$ rejects H_0 that variables are normally distributed (Zahediasl, 2012).

- H_0 : Variables are normally distributed.
- H_1 : Variables are not normally distributed.

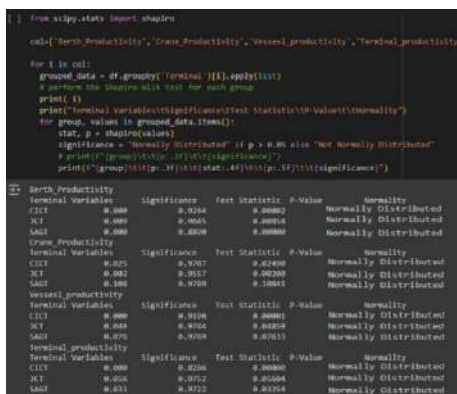


Figure 2 Normality Test

3.4.3 Descriptive Analysis

Central tendency measurements such as; means, standard deviations and standard errors, correlation, and graphical representations and interpretations utilizing tables, figures, matplotlib charts, heatmaps, scatter plots, boxplots, stacked bar charts, and pie charts were deployed.

3.4.4 Statistical Analysis

The data were first categorized as dependent and independent variables.

Independent Variable – Terminal

- JCT
- SAGT
- CICT

Dependent Variable – Productivity - Berth Productivity

- Vessel productivity
- Crane Productivity

4.0 Data Analysis and Technical Productivity Overview

Rigorously analyzes the technical productivity cranes, vessels, and berths across the JCT, SAGT, and CICT terminals at the Port of Colombo. The chapter employs comprehensive statistical techniques including descriptive statistics, ANOVA tests, and post hoc analyses to explore the nuanced differences and interdependencies among these terminals.

Technical productivity metrics such as crane operational hours, vessel handling efficiency, and berth utilization are pivotal in understanding operational efficiencies at these terminals. CICT emerges as a leader in crane productivity, boasting advanced operational capabilities attributed to its infrastructure investments and deep-water advantages. Conversely, JCT and SAGT exhibit varied performances in crane and berth productivities, reflecting differing operational strategies and infrastructure capacities.

4.0 Data Analysis

4.1 Analysis Visualization

4.1.1 Comparison Analysis of distributions of variables

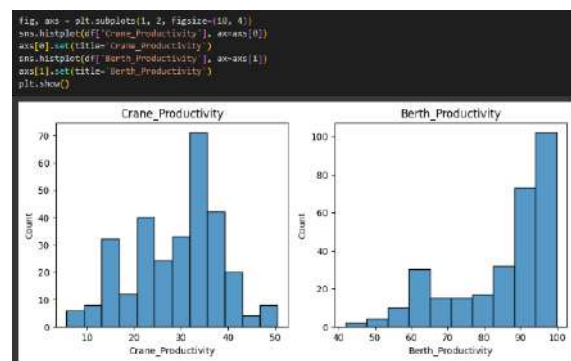


Figure 3 Comparison Analysis

4.1.2 calculation of correlation between the variables.

The correlation matrix shows positive relationships (0.77 to 0.28) among Total Moves, Real Gross Working Hours, and Gross Crane Operational Hours. Berth Productivity and Crane Productivity are moderately correlated (0.61/ 0.54), while berth Productivity shows high correlations with Total Moves (0.61) and Vessel Productivity (0.56). These findings provide insights into the interdependencies and dynamics within the dataset, guiding further analysis and decision-making processes.

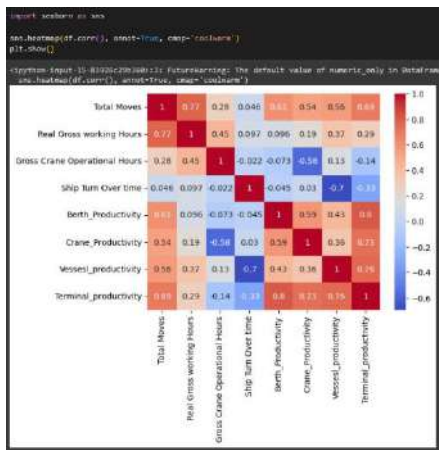


Figure 6 correlation matrix heatmap

4.1.3 Calculation of the Correlation coefficient

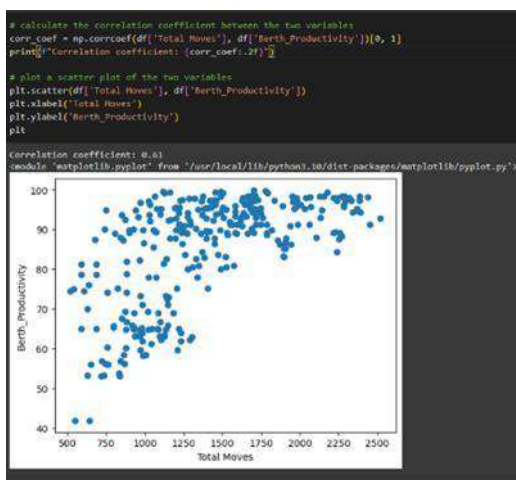


Figure 4 correlation matrix scatter plot

The scatter plot visually represents this relationship, showing a tendency for higher 'Total Moves' to correspond with higher 'Berth Productivity'. The points generally trend upwards, suggesting a positive linear association between the two variables. The correlation coefficient between 'Total Moves' and 'Berth Productivity' is 0.61, indicating a moderately positive relationship.

This visual comparison of 'Total Moves' versus 'Berth Productivity' across different terminals, each distinguished by a unique color and labeled in the legend. Adjustments can be made to colors, transparency, and other plot properties as needed for better visualization and analysis.

Overall those visualization analyses show all data set behaviors and the spread in all independent variables and all terminals (CICT/SAGT/JCT) correlation coefficients. Correlation matrices elucidate relationships between productivity metrics and operational variables like total movements and gross working hours. Strong correlations between crane operational hours and total movements suggest efficient resource allocation practices at high-demand periods, enhancing terminal throughput and operational reliability.

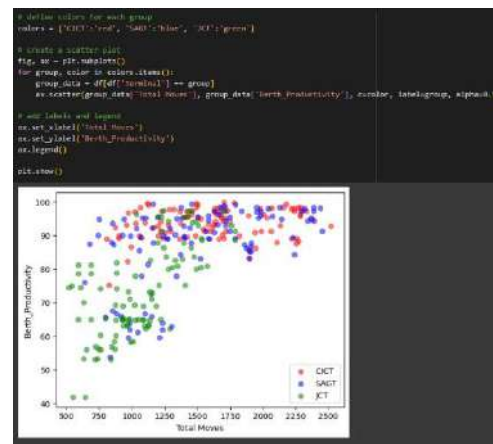


Figure 5 colors transparency plot.

4.2 Descriptive Analysis (BP/CP/VP) of JCT, SAGT, and CICT

The analysis of Vessel, Berth, and Crane Productivity across the JCT, SAGT, and CICT terminals reveals varying levels of performance. For Vessel Productivity, CICT averages 31.512, JCT averages 33.1718, and SAGT averages 31.0976, with no statistically significant differences across the terminals ($p > 0.005$). In terms of Berth Productivity, SAGT shows the highest average at 96.9058, followed by CICT at 105.5439 and JCT at 73.5018. ANOVA results indicate significant differences in Berth Productivity among the terminals ($p < 0.005$). Crane Productivity shows JCT with an average of 21.4812, SAGT at 30.3588, and CICT at 34.6618, with significant differences noted among the terminals ($p < 0.005$), highlighting CICT's superior performance in Crane Productivity.

While vessel Productivity did not show significant differences among terminals, both Berth Productivity and Crane Productivity demonstrated notable variations, with CICT generally performing better in terms of productivity metrics compared to SAGT and JCT at the Port of Colombo.

4.3 Implications for Terminal Management

The analysis of Vessel, Berth, and Crane Productivity across JCT, SAGT, and CICT terminals at the Port of Colombo reveals varied efficiencies. Vessel Productivity shows minimal variance, while Berth Productivity varies significantly, with SAGT leading and JCT trailing. CICT outperforms Crane Productivity, suggesting superior equipment utilization. These findings highlight the need for targeted improvements in berth management and crane operations. Future research should explore operational practices and technology integrations to enhance productivity and inform strategic investments for better port performance and customer satisfaction.

5.0 Implementation of the Design of the Solutions

5.0 Modeling and Evaluation

5.1 Introduction

This chapter ~~study~~ focuses on applying various prediction models to measure terminal productivity using the collected dataset. Drawing from Agarwal (2015), the chapter adopts a structured approach encompassing data cleaning, integration, transformation, discretization, and machine learning modeling. Data cleaning addresses missing or inaccurate data, ensuring dataset quality. Integration merges diverse data sources for comprehensive analysis. Transformation standardizes raw data for visualization and modeling. Data reduction minimizes dataset volume while preserving critical information. Discretization converts continuous data into bounded values. Python libraries support efficient data processing, modeling, and evaluation, enhancing analytic capabilities throughout the research.

5.2 Implementation of Modeling and Evaluation

5.2.1 Linear Regression Model

The Linear Regression model is a straightforward technique used widely for establishing linear relationships between variables. It models the relationship as “ $y = b_0 + b_1 * x_1 + b_2 * x_2 + \dots + b_n * x_n$ ”, where y is the dependent variable (Terminal Productivity in this study), and “ b_0, b_1, b_2 ” are coefficients. The model aims to minimize the difference between actual and predicted values.

Linear Regression Model

```
# Prepare new data for prediction
new_data = pd.DataFrame({'Berth_Productivity': [89.91],
                        'Crane_Productivity': [35.13], 'Vessel_productivity': [58.06]})

# Make predictions on new data
predictions = model_LR.predict(new_data)

print("Predicted Terminal_productivity:", predictions)

Predicted Terminal_productivity: [61.0988079]
```

Figure 9 Linear Regression Model

5.2.2 Lasso Regression Model

Lasso Regression, known for its feature selection capabilities, also models relationships between variables. It is represented as “ $y = \beta_0 + \beta_1 * X_1 + \beta_2 * X_2 + \dots + \beta_p * X_p$ ”, aiming to minimize prediction errors while maintaining model simplicity.

Lasso Regression Model

```
# Prepare new data for prediction
new_data = pd.DataFrame({'Berth_Productivity': [89.91],
                        'Crane_Productivity': [35.13], 'Vessel_productivity': [58.06]})

new2= scaler.transform(new_data)
# Make predictions on new data
predictions = lasso_model.predict(new2)

print("Predicted Terminal_productivity:", predictions)

Predicted Terminal_productivity: [60.98532049]
```

Figure 11 Lasso Regression Model

5.2.3 Polynomial Regression Model

When relationships between variables are non-linear, Polynomial Regression fits the equation “ $y = \beta_0 + \beta_1x + \beta_2x^2 + \dots + \beta_nx^n$ ”. The “ Y ”. This model captures more complex relationships between predictors and the dependent variable.

Polynomial Regression Model

```
# Step 1: Prepare the New Data
new_data = pd.DataFrame({'Berth_Productivity': [89.91],
                        'Crane_Productivity': [35.13],
                        'Vessel_productivity': [58.06]})

# Step 2: Polynomial Transformation
# Use the same PolynomialFeatures object that you used during training
new_data_poly = poly_features.transform(new_data)

# Step 3: Make Predictions
predictions = model.predict(new_data_poly)

print("Predicted Terminal_productivity:", predictions)

Predicted Terminal_productivity: [61.02244308]
```

Figure 7 Polynomial Regression Model

5.2.4 Random Forest Regressor Model

The Random Forest Regressor combines multiple decision trees to improve prediction accuracy. It is robust against overfitting and capable of handling complex relationships in data.

Random Forest Regressor Model

```
# Prepare new data for prediction
new_data = pd.DataFrame({'Berth_Productivity': [89.91],
                        'Crane_Productivity': [35.13],
                        'Vessel_productivity': [58.06]})

# Make predictions on new data using the trained RandomForestRegressor model
predictions = rf_model.predict(new_data)

print("Predicted Terminal_productivity:", predictions)

Predicted Terminal_productivity: [61.0433]
```

Figure 8 Random Forest Regressor Model

5.2.5 KNeighbors Regressor Model

KNeighbors Regressor is a non-linear regression algorithm that predicts outputs based on the average of the outputs of its nearest neighbors. It is suitable for datasets with local patterns and non-linear relationships.

KNeighbors Regressor Model

```
import pandas as pd
from sklearn.neighbors import KNeighborsRegressor

# Prepare new data for prediction
new_data = pd.DataFrame({'Berth_Productivity': [89.91],
                        'Crane_Productivity': [35.13],
                        'Vessel_productivity': [58.06]}) # Corrected feature name

# Make predictions on new data using the trained KNeighborsRegressor model
predictions = knn_model.predict(new_data)

print("Predicted Terminal_productivity:", predictions)

Predicted Terminal_productivity: [60.906]
```

Figure 10 KNeighbors Regressor Model

Table 1 Final Output Summary Table of the Models.

Model Name	Mean Squared Error	R-squared	Intercept	RMSE
Linear Regression	14.74	0.875	-0.21	0.23549
Lasso Regression	14.70	0.875	52.61	0.23445
Polynomial Regression	0.13	0.857	2.82	0.36719
Random Forest Regressor	2.84	0.965	-	1.6879
KNeighborsRegressor	5.08	0.938	-	2.2557

6.0 CONCLUSION

The study conducted an extensive analysis of productivity indicators across the Colombo port terminals CICT, JCT, and SAGT revealing significant operational disparities and their consequential impacts on productivity metrics. CICT demonstrated strategic efficiency through innovative practices such as the Twin lift crane system and "Hot seat System," effectively reducing operational downtime and enhancing throughput. In contrast, JCT faced challenges attributed to inefficient practices and cost discrepancies between day and nighttime operations, impacting its overall productivity performance. Notably, CICT's implementation of a "First come First through" approach in berth operations highlighted its superior productivity compared to JCT and SAGT. Utilizing advanced regression models Linear, Lasso, Polynomial, Random Forest, and KNeighbors Regressor the study identified Lasso as particularly adept in feature selection, achieving the lowest Root Mean Squared Error (RMSE). However, Linear Regression emerged as the optimal model overall for accurately predicting terminal productivity. Future research should explore additional metrics such as labor and financial productivity to provide a more comprehensive assessment of terminal operations and their broader economic implications.

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all! Thank you!

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The Effectiveness of Small Group Discussions in Teaching Speaking as a Skill for Grade 6 English as a Second Language Learners in Sri Lanka

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Abstract—Teaching speaking skills to English as a Second Language (ESL) learners poses a significant challenge, especially in contexts where English is not the primary mode of communication. Among various pedagogical approaches, Small Group Discussions have gained attention for their potential to enhance speaking proficiency. The present study aims to examine the effectiveness of small group discussions in improving the speaking proficiency of Grade 6 ESL learners in Sri Lanka while identifying the impact of small group discussions on student engagement and confidence in using ESL. The study employed a mixed approach and an experimental research design. Accordingly, sixteen Grade 6 ESL Learners with first language Tamil from Al-Mubarak National School were selected as the research samples using a simple random sampling method. During data collection, the

study used both quantitative and qualitative data collection methods. Quantitative data was collected through pre and post-tests while qualitative data was collected through observations. The quantitative data was analyzed by the researchers using MS Excel and the qualitative data was analyzed through a thematic analysis. The findings reveal that small group discussions significantly improve language skills, student engagement, vocabulary building, conceptualization of meaning, and constructs self-confidence in utilizing ESL. Thus, integrating small group discussions into the ESL curriculum can be instrumental in nurturing a supportive learning environment conducive to linguistic growth and learner empowerment.

Keywords: *English as a Second Language, Small Group Discussions, Teaching Speaking as a Skill*

I. INTRODUCTION

Speaking is regarded as the most important of the three language skills—reading, writing, and listening (Safitri et al., 2020). According to Brown and Yule (1983), in real-life situations, speaking is the skill on which students will be evaluated the most. With the growing importance of English as a language for international communication, there is a requirement for proficiency in speaking (Nazara, 2011). Hence speaking skills are not only essential for academic success but also for future opportunities in a globalized world. Therefore, the teaching of speaking skills becomes essential in English as a Second Language (ESL) education.

In teaching speaking as a skill, language teachers can employ several strategies in the ESL classroom. One such strategy is Small Group Discussion which according to Purba et al. (2020) is a cooperative learning technique that allows students additional chances to gather their thoughts, experiences, and knowledge and put them into speech by collaborating in small groups to support one another's academic subject acquisition. According to Ornstein and Levine (2000), small groups assist learners in improving their social and cooperative abilities while providing the opportunity to be actively involved in education and language development.

Given the significance of Small Group Discussions as a valuable pedagogical tool, the present study aims to examine the effectiveness of small group discussions in improving the speaking proficiency of Grade 6 ESL learners in Sri Lanka while identifying the impact of small group discussions on student engagement and confidence in using ESL. Through a comprehensive analysis, the study aims to offer practical recommendations for educators and policymakers seeking to enhance the speaking proficiency of Grade 6 ESL Learners in Sri Lanka. Hence, the questions addressed in the study are; (1) To what extent do small group discussions improve the speaking proficiency of Grade 6 ESL learners in Sri Lanka? (2) How do small group discussions impact student engagement and confidence in using English as a second language?

II. LITERATURE REVIEW

A. Educational Goals and English Language Teaching in Sri Lanka

With the invasion of the British due to colonization in 1796, English was introduced to Sri Lanka and has significantly influenced the Sri Lankan educational system. Since the late 1980s, the Educational System of Sri Lanka has advocated the use of a communicative method to teaching English in classrooms (National Institute of Education 1999).

With the national goal of the secondary education system being to create citizens ready to face the challenges of the twenty-first century (Ministry of Education, 2020), integrating the teaching of speaking skills becomes mandatory in the context of teaching English in Sri Lanka to enhance confidence and competence in using English within and outside classroom.

B. Theories Influential in Investigating the Effectiveness of Small Group Discussions in Teaching Speaking as a Skill for Second Language Learners.

Interaction Hypothesis

The Interaction Approach by Gass and Mackney (2007) or the Oral Interaction Hypothesis by Ellis (1991) which was initially proposed by Long (1981) is influential in investigating the effectiveness of small group discussions in teaching speaking as a skill for second language learners. The Interaction Hypothesis makes two main assertions regarding the function of interaction in learning a second language. It asserts that learning a second language requires comprehensible input and that adjustments to the interactional structure of discussions make input more understandable for a second language learner (Ellis, 1991). In addition, the hypothesis claims that interaction causes students to focus on something novel, like a new word or grammatical structure, thus promoting the development of the second language (Gass & Mackney, 2007). Interaction via the meaning of negotiation is seen as the catalyst to obtain comprehensible language (Long, 1983). Although Long (1983) maintains that understandable input is essential for learning, he acknowledges that it could not be enough (Long, 1989). However, Long (1983) fails to specify when or how it is insufficient whether its inadequacy stems from the fact that its contribution depends on another element or variables like that of Krashen's (1982) affective filter or from the fact that it does not fully explain acquisition as White (1987) contends. Nevertheless, the Interaction Hypothesis has advanced pedagogical research on second language acquisition by emphasizing the language classroom as a space where contexts for interaction are intentionally created, rather than just a place where students from different backgrounds, skill levels, and styles interact (Brown, 2007). Thus, the hypothesis is influential in investigating the effectiveness of small group discussions in teaching speaking as a skill for Grade 6 ESL learners in Sri Lanka.

Output Hypothesis

The Output Hypothesis by Swain (1985) is influential in investigating the effectiveness of small group discussions in teaching speaking as a skill for second language learners. Swain (1985) claims that using the target language may serve as a catalyst in making the learner aware of the necessary modes of expression to effectively communicate their own intended meaning (Swain, 1985, p. 249). It is argued that engaging in production provides second-language learners with

the opportunity to produce accurate, logical, and relevant messages since output helps in noticing linguistic gaps, provides negative feedback, and also provides the learner more metalinguistic knowledge by acting as a hypothesis-testing tool (Swain, 1995, pp. 125–126). According to the hypothesis, input does not drive language learning; rather, output drives learners to analyse language more profoundly and mentally than input, enabling them to generate more correct language (Swain, 1995, p. 125). Supporting the claim of Swain (1985), the study of Mackey (2006) identifies from a learner's perspective that the output produced facilitates in generating correct language through the opportunity it produces to receive meaningful feedback from others. However, the Output Hypothesis (Swain, 1985) is criticized by several scholars including Ellis (1998) who argues that output may enhance fluency but not accuracy. Nevertheless, as Wei (2018) states, the Output Hypothesis (Swain, 1985) has a significant influence on second language teaching and hence is influential in investigating the effectiveness of small group discussions in teaching speaking as a skill for second language learners.

C. Prior Studies about the Effectiveness of Teaching Speaking as a Skill through Small Group Discussion

In recent years, there has been a growing body of literature investigating the effectiveness of teaching speaking as a skill through small group discussions. A recent study by Rosadi et al. (2020) investigated the use of Small Group Discussion strategy in teaching English speaking using a descriptive qualitative method for grade seven students at SMPN 3 Ciawi, Indonesia. The study identifies that the Small Group Discussion strategy builds learner confidence in speaking while engaging students through discussion providing language learners with the opportunity to improve speaking skills. Nevertheless, the study identifies that the active involvement of only smart learners and the continuous distraction because of noise during discussions may hinder the effectiveness of teaching English speaking through small group discussions.

Another recent study by Moge and Oroh (2022) investigating the application of small group discussions in enhancing students' speaking ability at SMA Negeri 1 Poigar using a Classroom Action Research (CAR) design identifies that there is a significant improvement in the student's ability to use pronunciation, intonation, vocabulary, and fluency through small group discussions. Moge and Oroh (2022) identify that the Small Group Discussion strategy not only improves speaking ability but also facilitates students to express ideas confidently without hesitation. Despite recent studies examining the effectiveness of small group discussions in teaching speaking as a skill in ESL contexts similar to Sri Lanka, there is a lack of comprehensive studies investigating the effectiveness of small group discussions in teaching speaking as a skill for ESL learners within the Sri Lankan context. Given the

unique cultural and educational context of Sri Lanka, which has been significantly influenced by its colonial history and current national educational goals, it is crucial to examine whether the benefits and challenges identified in other contexts apply similarly in Sri Lankan classrooms. Understanding this will provide valuable insights into the applicability and effectiveness of small group discussions as a teaching strategy for enhancing speaking skills among Sri Lankan students. Therefore, by examining the effectiveness of small group discussions in improving the speaking proficiency of Grade 6 ESL learners in Sri Lanka while identifying the impact of small group discussions on student engagement and confidence in using ESL, the present study attempts to contribute to existing literature on ESL education.

III. METHODOLOGY

The study employed a mixed approach and an experimental research design. Accordingly, sixteen Grade 6 ESL Learners with first language Tamil from Al-Mubarak National School in the Gampaha District were selected as the research samples using a simple random sampling method. The research samples were separated into two classes where eight students formed the experimental class and eight students formed the control class. In collecting data for the study, the study used a combination of quantitative and qualitative data collection methods. Quantitative data was collected through pre and post-tests to measure learners' speaking skills before and after the intervention while qualitative data was collected through observations of small group discussions. In addition, secondary data was obtained through library research and the Internet. The quantitative data was analyzed by the researchers using MS Excel and the criteria proposed to mark pronunciation, grammar, vocabulary, fluency, and comprehension by Harris (1969) were used in evaluating learners' performance in the pretest and posttest. In contrast, qualitative data was analyzed through a thematic analysis where the identified patterns during observations were categorized into common themes. The experimental class was divided into small groups with four in each to facilitate discussion. The discussions were conducted for two days allowing for sufficient intervention and data collection.

H. Analysis of Data

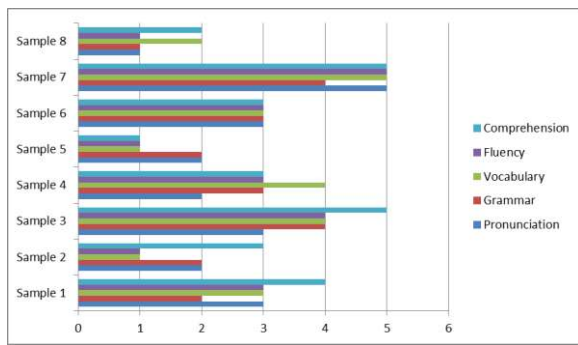


Figure 1. Pretest Data of Experimental Class

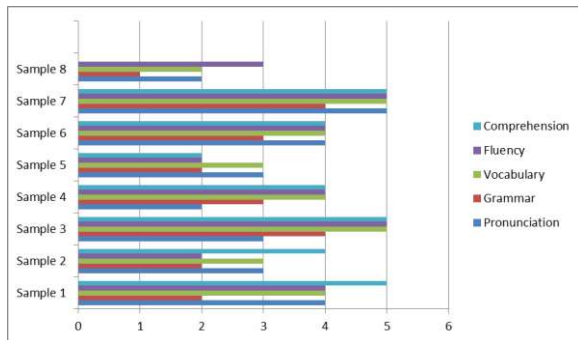


Figure 2. Posttest Data of Experimental Class

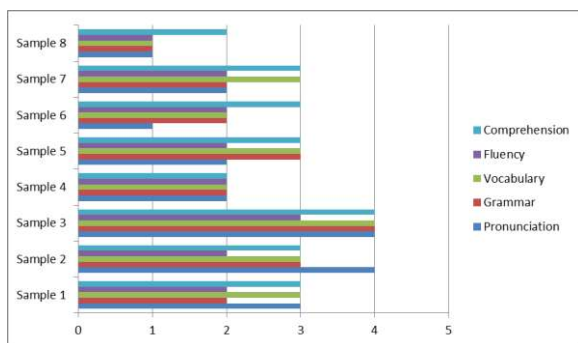


Figure 3. Pretest Data of Control Class

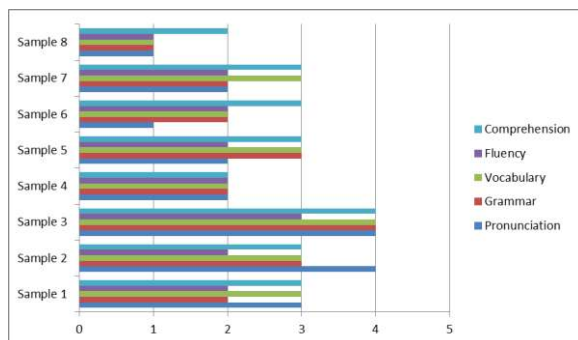


Figure 4. Posttest Data of Control Class

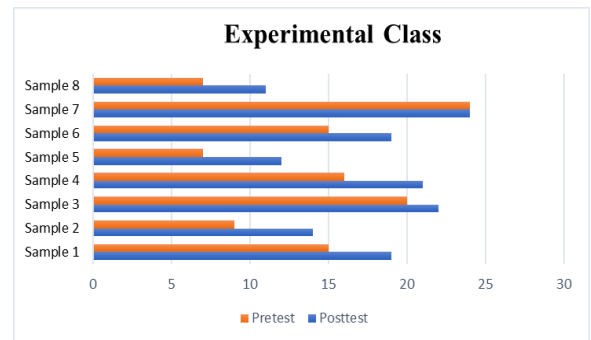


Figure 5. Pretest Vs Posttest Overall Data of Experimental Class

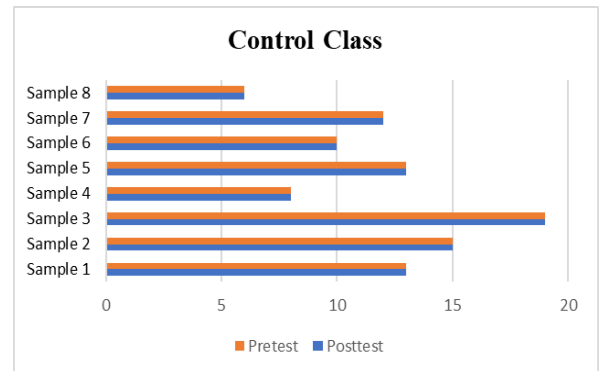


Figure 6. Pretest Vs Posttest Overall Data of Control Class

IV. RESULTS AND DISCUSSION

The findings of the study are presented under four themes and are discussed in accordance with the two research questions.

A. Student Initialization

Unlike in the control class where the teacher acts as an initiator, the samples in the experimental class practiced and engaged in active learning of the language while receiving meaningful feedback from peers through initiating conversations during discussions. This improved their speaking proficiency and contributed to their active engagement in the lesson which is indicated by the significant difference between the pretest and posttest results of the experimental and control class (see Figure 5, Figure 6). This finding consolidates with the explanation of Aflah and Rahmani (2022) that group discussions inculcate student autonomy which is an important factor in second or foreign language teaching. In addition, the finding also approves the statement of Purba et al. (2020) that Cooperative learning gives students more influence over the teaching and learning process in the classroom since each team member is accountable for the team's performance.

B. Vocabulary Building

The findings also reveal that during small group discussions, learners identified the gaps in their knowledge of the lexicon and were engaged in building vocabulary by clarifying unknown words during interaction. Referring to one such instance observable during the small group discussion:

Student A: “*oonjal* (*oonjal*!) what English?”

Student B: “Swing swing”

Accordingly, it is evident that group discussions introduced new vocabulary, provided the language learners with comprehensible input, and encouraged them to push output while developing speaking proficiency. This finding aligns with the claim of Gass and Mackney (2007) that interaction causes students to focus on something novel, like a new word or grammatical structure, thus promoting the development of the second language. This is an indicator to language practitioners to employ activities with an information gap which can be filled through interaction during small group discussions.

C. Conceptualization of Meaning

Unlike in the control class where the students were passive listeners, the experimental class was engaged in conceptualizing meaning through negotiation during interaction. One such instance is highlighted below:

Student A: “That is sun rising”

Student B: “rising mean?”

Student C: “Like stand up, coming out”

The above instance indicates the learners attempt to conceptualize meaning by making connections between their words and their understanding and participating in the small group discussion by sharing experiences and thoughts in conceptualizing meaning. This finding reinforces the claim of Long (1983) that interaction is a catalyst for obtaining comprehensible language. However, while conceptualizing meaning, there is a lack of attention paid to grammar and accuracy hence the posttest of the experimental class indicates no improvement in grammar but only fluency (see Figure 2). The finding deviates from the claim of Swain (1985) that output generates correct language aligning with the argument of Ellis (1998) that output enhances fluency not accuracy.

D. Construction of Self-confidence

Different from the control class, participants in the experimental class displayed an increased self-confidence which is indicated by the significant improvement in the experimental class's speaking proficiency in the posttest (see Figure 2). This reveals that group discussions result in learners constructing self-confidence in using the target language because of the meaningful feedback they receive from peers during interaction. It also reveals that group discussions intrinsically motivate learners impacting their engagement and confidence in using the target language. This finding aligns with the findings of Rosadi et al. (2020) and Moge and Oroh (2022) who

also investigated the effectiveness of small group discussions in teaching speaking as a skill.

V. CONCLUSION

In conclusion, this research highlights the effectiveness of small group discussions in enhancing the speaking proficiency of grade 6 ESL learners in Sri Lanka. Through investigation, it becomes evident that small group discussions not only strengthen language skills but also cultivate student engagement and confidence in utilizing English as a second language. These findings hold substantial implications for educators and policymakers globally, emphasizing the invaluable role of interactive and collaborative learning strategies in fostering linguistic development and boosting students' overall language competence and confidence. Moving forward, integrating small group discussions into ESL curriculum frameworks can be instrumental in nurturing a supportive learning environment conducive to linguistic growth and learner empowerment.

A.Limitations and Directions for Future Research

The study identifies the effectiveness of small group discussions in teaching speaking as a skill for grade 6 ESL Learners in Sri Lanka through a representative group of learners whose first language is Tamil with a limited sample of the study. Thus, the small sample size and specific context may limit the generalizability of the findings. Additionally, individual differences in terms of learning styles, prior English learning experiences, and proficiency levels which were disregarded during sampling could have influenced the results. Therefore, the study directs future researchers to use cross-cultural studies on a larger sample and explore how cultural factors influence the effectiveness of small group discussions in improving speaking proficiency and confidence in using English as a second language. In addition, it directs future researchers to regard individual differences by incorporating measures to account for diverse learning styles, language backgrounds, and proficiency levels to provide a more comprehensive understanding of the effectiveness of small group discussions in teaching speaking as a skill for English as a Second Language learners.

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Assessing the Impact of Agricultural Schemes on Paddy Yield in the MahaSeason in Sri Lanka: A Comprehensive Analysis of Major, Minor and Rainfed Schemes from the year 2020 to 2023

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Abstract— This research aims to provide a comprehensive analysis and deep understanding of the agricultural schemes; minor, major and rainfed impact on the paddy cultivation and paddy harvest across different districts during the Maha Season in Sri Lanka. For this study, a quantitative methodology approaches of comparative analysis, Correlation Analysis, Time Series Analysis and K- Mean Clustering Algorithms were used for data exploration and finding the Agricultural schemes' (Minor, Major, Rainfed) impact on the paddy cultivation throughout the time period from the year 2020 to the year 2023. How the weather conditions and different agricultural schemes in Maha

Season affect the total paddy production during each year and how it impacts on cultivation and yield are discussed in detail for further understanding of the contribution of paddy harvesting to the overall agricultural sector in Sri Lanka.

Keywords—Paddy Cultivation, Quantitative approach, Agricultural Schemes, Maha Season

I. INTRODUCTION

With the growth of the population as a whole the need for better necessities such as food increases [1] in a

significant percentage. As the major staple food in Sri Lanka, specifically paddy cultivation is considered as one of the main crop cultivations carried out in respective cultivating seasons Maha and Yala [2]. Paddy, being considered as a wetlands crop, is cultivated in all parts of Sri Lankan districts, whereas Sri Lanka is an agricultural country that contributes more than forty percent (40%) to the working population engaged in the agricultural sector [3] supporting the Sri Lankan economy standing as a backbone.

There are mainly two cultivation seasons namely Yala and Maha which are synonymous with two monsoons. The

Maha season falls during the “North-east monsoon” from September-October to March in the following year, while Yala Season is effective during the period from April to the end of August-September [4]. The particular season is defined by when the crop is sown and harvested during the said periods above. Paddy, being the widely planted crop in Asian countries, requires more water than other crops making it vulnerable to any other climates resulting crop destruction and wastage once these don't meet the required hydrated level. These factors affect the declines in the crop yields which eventually leads to the lack of the food security [5]. Considering that Sri Lanka is a country with heavy short rains and longer periods of drought e paddy cultivation along with maintaining the productivity of the overall agricultural sector is challenging.[5].

A. Paddy Cultivation

Paddy, the initial form of the Sri Lankan staple food is one of the main crop cultivations that is carried out in the agricultural sector of Sri Lanka. Rice is prominently grown across Sri Lanka in Maha and Yala seasons specifically the monsoon seasons, and they are considered as the major and minor seasons respectively including the intermediate zone adhering to the monsoonal peaks of northern and southern monsoons [6]. Paddy as the backbone of Sri Lankan agriculture supports; however, the crop is very much vulnerable and easily affected by the climate and water resource changes [7], yet the paddy cultivation contributes the most for the Sri Lankan agricultural economy. Water is a crucial factor for the upbringing of the paddy crop cultivation, and paddy can also be considered as a semiaquatic plant under controlled water supply environment [7], whereas paddy cultivation spreads throughout the districts all around Sri Lanka securing the harvest to an acceptable extent

under the agricultural schemes discussed throughout this research.

B. Maha Season

The crucial season of agriculture in Sri Lanka is the period between October to March known as the Maha Season, which is considered as the main season where the paddy is grown. Most of the cultivation lands are nourished during this season increasing the paddy harvest compared to Yala season where the paddy cultivation can be estimated as half of what is grown in Maha season. Yala season has the less water supply compared to the main monsoon season Maha [8].

C. Agricultural Schemes

Agricultural schemes considered in this research study are of three main types: minor, major and rainfed agricultural schemes. Considering the monsoonal peaks of northern and southern monsoons, the significant changes between the schemes are explored during the Maha season. Throughout this study the variations on the paddy cultivations and the paddy harvest are explored for a better knowledge and deep understanding on the different agricultural schemes. This study mainly focuses on the Maha season's paddy cultivation and the respective yields obtained.

II. PROBLEM STATEMENT

Rice being the staple food of Sri Lankan people, the paddy cultivation, taking place in the Maha season (October – March), is a crucial period of the agricultural sector in Sri Lanka along with the Yala Season (April – September). This study aims to analyze the paddy cultivation and yield distribution of agricultural schemes, Minor, Major and rainfed across different districts of Sri Lanka in the Maha Season. Through a detailed examining of the impact of these agricultural schemes on the paddy cultivation yield, this research aims to seek deep understanding and an analysis of how the allocation and implementation of these agricultural schemes (Minor, Major, Rainfed) affect to the production outcomes, specifically the paddy cultivation in return shed light on paddy cultivation and agricultural schemes effectiveness and efficiency during the Maha season in Sri Lanka, that provides valuable insights and information for the Policymakers, agricultural practitioners and other stakeholders involved in the development of agriculture and food safety initiatives.

III. OBJECTIVE OF THIS

STUDY The main objectives of this research are:

- i. To investigate the relationship between the Minor, Major, Rainfed agricultural schemes

and the paddy cultivation yield during the Maha Season in Sri Lanka.

- ii. To examine the extent of the agricultural schemes' distribution across different districts in Sri Lanka.
- iii. To compare the efficiency and the effectiveness of Minor, Major and Rainfed agricultural schemes with regard to the paddy yield during the Maha season.
- iv. To provide valuable insights into optimizing the allocation and implementation of Minor, Major, Rainfed agricultural schemes in order to enhance the production and the food safety in Sri Lanka.
- v. To provide information to the policymakers, agricultural practitioners and the stakeholders regarding the implications and upliftment of agricultural schemes on the paddy cultivation and the paddy yield in the Maha season in Sri Lanka.

IV. METHODOLOGY

This research aims to use a quantitative approach to analyze the impact of the agricultural schemes Minor, Major and Rainfed effect on the paddy cultivation and the paddy yield during the Maha season in different districts across Sri Lanka.

The data for this study was taken from the authoritative sources like the Department of Agriculture and other government agencies [9]. where it shows the relevant data resources in the site, we gathered from the reports to extract and marked up the needed data as a dataset comprised of the years from 2020 to 2023. The dataset consists of all the Sri Lankan districts that carry out the paddy cultivation. Missing values were present in the dataset, which explains the dataset created to be an imbalanced dataset.

The data collected was specified into the districts according to the agricultural schemes Major, Minor and rainfed based on the irrigation infrastructure and the water availability, further classified as Gross Extent Sown and Gross Extent Harvested to the Average Yield of paddy in the three schemes, net Harvest and total production of paddy overall figures. Values appeared in Acres of cultivation and harvesting where Bushels were for the total production reported.

The dataset created from the extracted data appeared to be imbalanced with missing values, therefore data preprocessing task was carried out in order to ensure

accuracy and consistency of the data used for the analysis study.

A. Comparative Analysis

The Comparative Analysis was performed across the reported agricultural schemes; Minor, Major and Rainfed, examining the key metrics like average yield per acre, total production, and the extent harvested. Statistical techniques like mean comparison tests were employed to identify significant differences in the crop yield.

B. Time Series Analysis

The Time Series Analysis was performed to examine the trends and the patterns in the paddy yield over the period of the research study (2020-2023).

C. Correlation Analysis

The Correlation Analysis was conducted to explore the relationship between Minor, Major and Rainfed agricultural schemes during the paddy cultivation and the paddy yield.

D. Clustering Algorithm

The K-Means Clustering Algorithm was performed in order to identify the clusters of between the Paddy yield in different Agricultural Schemes reported in the data of paddy cultivation and harvest.

V. FINDINGS

A. Comparative Analysis

Through the Comparative Analysis, the total production for the time period of year 2020 – year 2023 were taken into a line chart for better understanding where the production variations throughout the considered time were visualized.

According to Fig.1 below the variation of Sum of total bushels production ('000 bushels) in each district. This plot highlights that Anuradhapura, Ampara, Kurunegala & Polonnaruwa shows the highest yields out of all districts in each of the three years from 2020 – 2023.

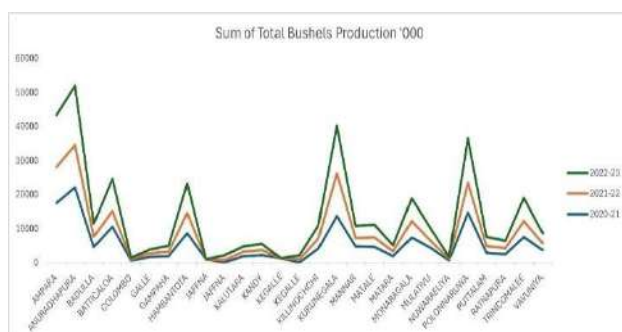


Fig.1. Comparative Line Chart – total paddy production per each district

The below Fig.2 shows the pie chart that visualize the Sum of total bushels of paddy production ('000 bushels) in each year from year 2020 - 2023. As per the plot, it shows that the year 2021-22 has a comparatively less total yield of paddy amounting to 92,556,000 bushels compared to 2020- 21 production that amounts to 146,720,000 bushels and 129,212,000 bushels of paddy yield for the year 2022-23.

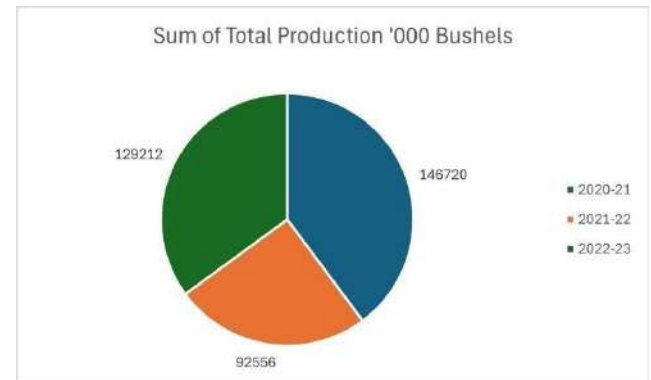


Fig.2. Pie chart of total paddy production yield per tear

The regional comparison of the total paddy harvest with respect to each district based on the three agricultural schemes; Minor, Major and Rainfed is shown as a Vertical Bar Chart in Fig.3. below, where the highest yields are reported in the Major scheme in the districts Hambantota, Ratnapura, Monaragala. The lowest Yields are reported in Rainfed Scheme in the districts Mannar, Jaffna, Trincomalee and Batticaloa where Minor scheme reports values in between highest figures and the lowest yield figures.

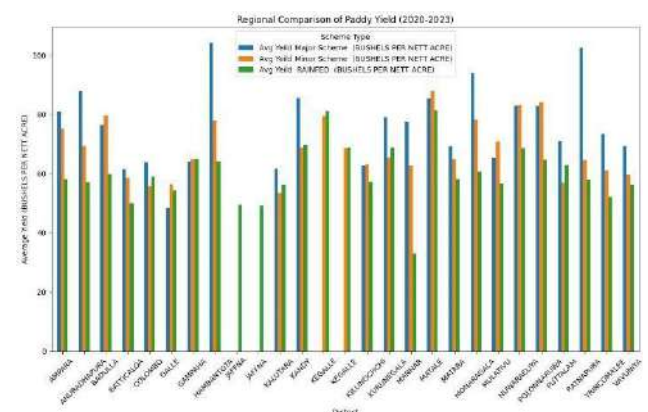


Fig.3. Vertical Bar char of Regional Comparison of paddy harvest

B. Time Series Analysis

The Paddy cultivation harvest in each year from 2020 to year 2023 are taken for a trend analysis performed on the Average paddy yields in each agricultural scheme of Minor, Major and Rainfed schemes, where the yield trends have significantly increased throughout the time periods from the year 2020 to 2023. Highest trend is with the Major Agricultural Scheme

where the Lowest trend can be seen

with the Rainfed Scheme. In the year 2021-22, there can be seen the gradual decrease in the paddy harvest in all the three agricultural Schemes.

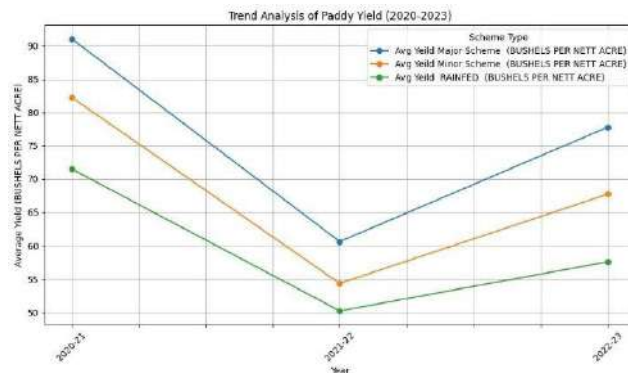


Fig. 4. Trend analysis plot of paddy yield in different schemes

Accordingly, a stacked bar chart as shown in Fig.4. was created in order to compares the average yield of the three different agricultural schemes; Minor, Major and Rainfed schemes over a span of three years figuring to the years from 2020-21, 2021-22 and 2022-23. The key points to understand through this plot is as follows; The highest yield across all three years consistently appears in the Major agricultural scheme that appears to be the most effective scheme in terms of Crop productivity, where the Rainfed Scheme shows the lowest yield and its productivity and performance seems to fluctuate throughout the time period. Minor Scheme shows moderate yield pattern slightly lower than the Major Agricultural scheme's performance and productivity, yet it still contributes positively to the crop productivity.

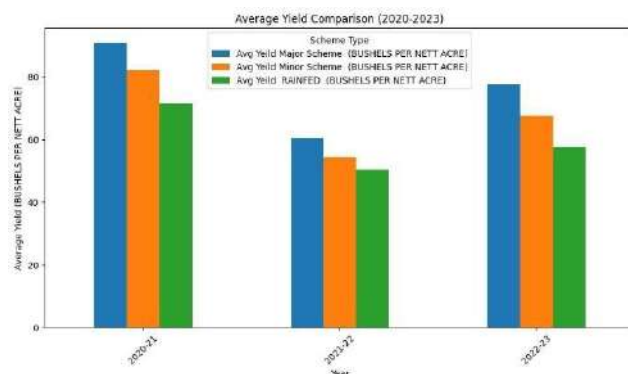


Fig. 4. Stacked bar chart of yield patterns of each agricultural scheme.

C. Correlation Analysis

The Correlation matrix as shown in Fig.5. show the coefficient and the correlation between the Agricultural Metrices and the Weather conditions. Each cell in the matrix shows the correlation coefficient between two variables where the color gradients indicate the strength and the direction of the correlations.

Color gradients:

- Red: Positive Correlations (values close to 1)
- Blue: Negative Correlations (values close to -1)
- White: Weak or no Correlations (values around 0)

Correlation results:

Positive Correlations:

- Gross Extent Sown Major Scheme (ACRES) has a strong positive correlation with Gross Extent Sown All Schemes resulting a coefficient of 0.87, which explains when the Major scheme paddy harvest increases the overall extent harvested across all three schemes tends to increase.
- Average Yield Major Scheme has a positive relationship with Average Yield Minor Scheme resulting a coefficient of 0.64, which explains when the Major scheme yields more the Minor scheme tends to yields more as well.

Negative Correlations:

- Average yield Rainfed scheme has no correlation with Gross Extent Harvested Minor scheme (ACRES) resulting a correlation coefficient of - 0.03, which makes both the variable independent to each other.
- Gross Extent Sown Rainfed (ACRES) negatively correlates with Gross Extent Harvested Minor Scheme (ACRES) resulting a correlation coefficient of -0.27, which explains when one Rainfed scheme extent harvest increases then the other Rainfed scheme extent harvest tends to decrease.

Weak Correlations:

- Gross Extent Harvested All Schemes (ACRES) has a weak positive correlation with Average yield Major Scheme (ACRES) resulting a correlation coefficient of 0.19, which explains there is a slight association between these variables.

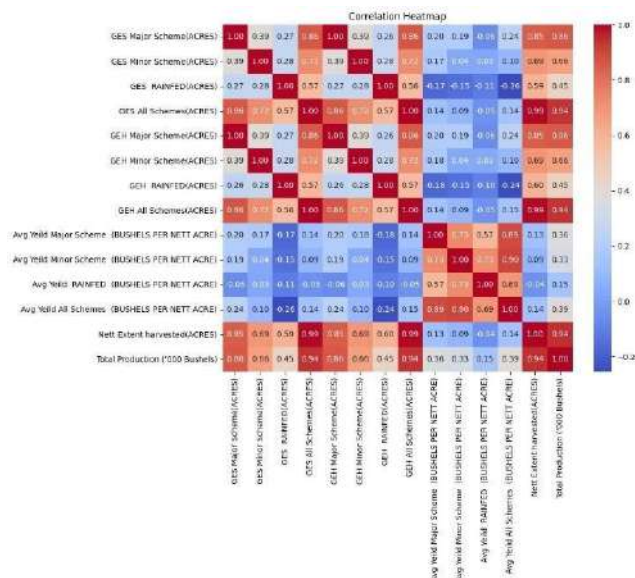


Fig. 5. Correlation matrix of agricultural schemes and weather conditions.

D. Clustering Algorithm

A K-Means Cluster plot was created in order to cluster the paddy production between Average Yield Major scheme and Average Yield Minor scheme where each cluster point corresponds with a specific combination of average yields in both schemes. The cluster plot shown in Fig. 6. Depicts the clusters of combinations relevant for both the schemes Minor and Major. The Purple cluster that is concentrated to the left-lower corner of the plot shows the lower yields of both the agricultural schemes resulting suboptimal yield performance. The Yellow Cluster occupies the mid-range values for both the schemes resulting moderate yield performance that is likely to correspond with optimal yield performance. The Blue Cluster that spreads through the right-upper corner of the plot that depicts higher yields for both minor and major schemes resulting higher corresponding with optimal yield performance.

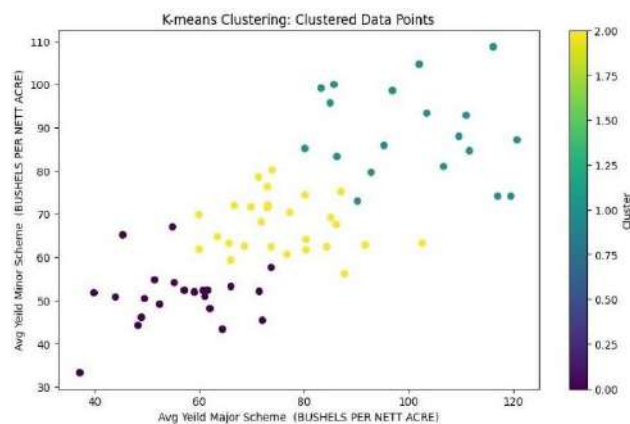


Fig.6. Cluster plot for yield combination

Accordingly, a clustering agricultural matrix that provides deep insights on different agricultural performance arranged

into six different panels in grid format is shown in Fig.7. Plot below explanations are as follows:

Top Left Panel: Average Yield Vs. Net Extent Harvested This scatter plot compares the average yield against the net extent harvested (in acres). Each dot represents a specific year: blue for the year 2020-21, orange for the year 2021- 22, green for the year 2022-23.

Top Left Density Plot: Distribution along Average Yield Axis

The density plot complements the scatter plot by showing the distribution of average yield values.

Middle Left Panel: Net Extent Harvested Vs. Total Production

This plot helps to explore the relationship between the area harvested (in acres) and total production ('000 bushels).

Bottom Left Panel: Total Production Vs. Average Yield This Scatter plot shows the total production in '000 bushels against the average yield (all schemes combined).

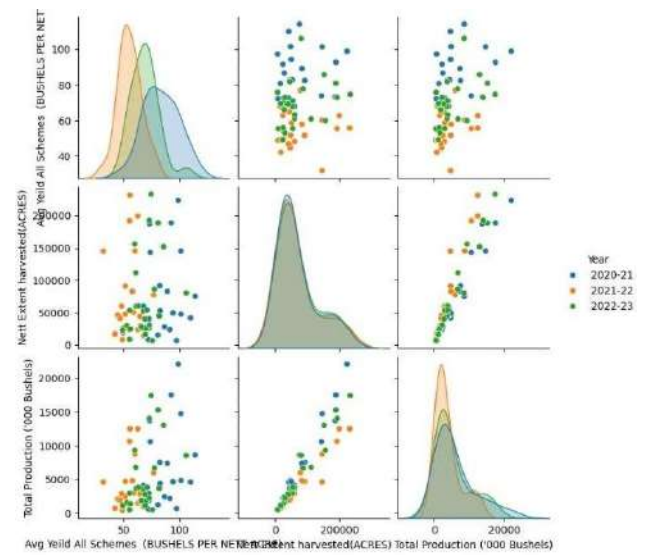
Bottom Left Density Plot: Distribution along Total Production Axis

This density plot highlights the distribution of total production values.

Plot Summary:

- 2020-21: high yield and substantial production
- 2021-22: moderate yield and consistent harvest area
- 2022-23: lower yield and narrower harvest extent

Fig.7. Clustering and density plot of agricultural schemes



E. Year-on-Year Growth Comparison

The growth per each year on paddy cultivation and harvesting comparison is as follows:

For the year 2020-21, since there weren't any data related to the previous year, year-on-year growth could not be performed to the year 2020-21.

Year	Average Yield Major Scheme	Average Yield Minor Scheme	Average Yield Rainfed Scheme
2020-21	NaN	NaN	NaN
2021-22	-33.426758	-33.940275	-29.776821
2022-23	28.332472	24.643670	14.672030

Table.1. Growth comparison table

VI. CONCLUSION

The current study emphasizes that throughout the paddy cultivation and yield proportions noted in the Maha season have significant changes throughout the time period of the year 2020 to year 2023. When considering the agricultural schemes, minor, major and rainfed, the major season is considered to have a greater contribution with regard to both paddy cultivation and yield when compared to the rest of the agricultural schemes reported in the dataset during the Maha season. Apart from these the regional changes or the value difference, among the listed Sri Lankan districts are noticeable with regard to the paddy cultivation and the harvest during the time span of three years reported from the year 2020 to year 2023.

VII. FUTURE WORKS

The future research based on the paddy cultivation and crop harvesting should focus on having a deep understanding and exploring of newer techniques that are in aid of improving the agricultural sector along with relevant implications. Developments needed to the agricultural sector specifying the paddy cultivation and paddy harvesting that are a source of influence in the policy makes, agriculture practitioners and other stakeholders' decision making regarding the upliftment and further development and stability of the agricultural sector as a whole which provides a major contribution to the Sri Lankan Economy's GDP.

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Exploring the Migration Intentions and Motivations among Sri Lankan Youth : A Sentiment Analysis Perspective

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Abstract - This study uses sentiment analysis as a technique to explore the complex intentions and motivations that lead young Sri Lankans to think about migrating. This study examines the fundamental determinants impacting the migratory tendency of Sri Lanka's youth demographic, with the goal of improving knowledge of the socio-economic dynamics driving movement within this population. The study, which makes use of sentiment analysis techniques, clarifies young Sri Lankans' views of opportunities in the country as well as their attitudes regarding migration. The conclusions drawn from this investigation have important ramifications for decision-makers, providing insightful information for initiatives targeted at retaining talent and promoting socioeconomic development in Sri Lanka.

Keywords- *Sentiment Analysis, Migration, Power Automate, K-means Clustering, Sri Lankan Youth.*

I. INTRODUCTION

Globally, the growing trend of youth migration has raised serious concerns in recent years, and Sri Lanka is not an exception. This issue, sometimes called "brain drain," is the result of educated and skilled people leaving their home country in search of better chances overseas. It represents a significant loss of potential. Brain drain has had a significant negative influence on Sri Lanka, impacting both the nation's socioeconomic situation and prospects for future growth. Due to a confluence of perceived greater possibilities abroad and socioeconomic issues, there has been a notable exodus of young, educated Sri Lankans. This research seeks to delve into

the underlying motivations and intentions behind the migration desires among Sri Lanka Youth.

These young people's migration is impacted by a complex interaction of social, cultural, and psychological elements and is not just a result of their desire for financial advancement. A feeling of disillusionment among young people has been exacerbated by high rates of youth unemployment, few professional options, unstable political environments, and improvements in education. The dearth of local prospects limits many young Sri Lankans, even in the face of advancements in healthcare and education.

Youth in Sri Lanka now has access to a wider range of options outside of their country due to globalization and technology improvements. This global viewpoint is essential to identify themigratory intents, which are motivated by personal fulfillment, cultural enrichment, and educational goals in addition to economic ones. These incentives have their roots in the social structure and are shaped by aspirations, cultural norms, and familial relationships.

Utilizing sentiment analysis, this study aims to provide a nuanced understanding of how young Sri Lankans perceive migration and their home country. This method, which applies natural language processing techniques, is particularly adept at deciphering the emotions, attitudes, and intentions expressed by individuals, offering an in-depth look at the driving forces behind migration trends. By analyzing sentiments expressed in

various forums and platforms, this research will capture the emotional and cognitive aspects of the migration decision-making process among Sri Lankan youth.

This study's ultimate objective is to provide information and direction for policy responses that tackle the underlying causes of migration and advance sustainable development in Sri Lanka. Policymakers can better design their policies to stop brain drain and increase the appeal of staying in Sri Lanka, hence fostering the future of the nation, by understanding the attitudes and motives of the country's youth.

A. Research Objectives

The study utilizes machine learning algorithms and sophisticated sentiment analysis techniques to examine textual data gathered from questionnaires that filled by young Sri Lankans. By using this method, the study hopes to give a thorough grasp of the youth migration landscape in Sri Lanka, which would help with better informed policy creation and decision-making.

The primary goal of this study is to investigate migration intentions and reasons among Sri Lankan adolescents using sentiment analysis. Specifically, the study aims are listed below:

1. Analyze the sentiments and emotions conveyed by Sri Lankan emigrants regarding their experiences and challenges in Sri Lanka
2. Investigate the multifaceted reasons that make certain countries more appealing to individuals to migrate from Sri Lanka
3. Synthesize the findings from sentiment analysis to formulate recommendations aimed at curbing brain drain in Sri Lanka

A. Defining Brain drain and General effect of migration to a home country.

[1] Brain drain, a term coined in the 1960s, describes the migration of skilled individuals from one country to another, often from less developed to more developed nations (Khadria, 2016). Scholars, policymakers, and economists have paid close attention to this phenomenon because of its far-reaching ramifications for both the countries of origin and destinations.[2] For countries of origin, brain drain can lead to a loss of human capital and expertise, hindering economic development and innovation (Bhagwati & Dellalgar, 1973)

[3]This loss can be particularly detrimental in sectors such as healthcare and education, where skilled professionals are essential for societal well-being (Beine et al., 2008).[1] On the other hand, destination countries benefit from an influx of

talent, contributing to economic growth and innovation (Khadria, 2016).

B. Sentiment Analysis Perspective of Sri Lankan Youngers on Migration Intention

Understanding the perceptions and intentions of young Sri Lankans toward migration is critical, especially given Sri Lanka's status as a developing country and the current brain drain crisis. Despite succeeding in progress in a variety of sectors, Sri Lanka continues to encounter challenges as a developing country.[4] Young Sri Lankans feel frustrated and disillusioned due to high levels of unemployment, restricted professional prospects, and inadequate infrastructure (Fernando & Gunawardana, 2018). These characteristics, together with political instability and economic uncertainty, impact the youth's perceptions of their country's prospects.

[5]According to the most recent data, approximately 311,056 Sri Lankans left the country for foreign employment in 2022, resulting in a monthly departure rate of over 29,000 people. A detailed examination of the data for the same year shows that the number of people leaving the country for professional-level jobs increased by 4.6%, but the number of low-skilled employees significantly increased by 33.92%. Forecasts based on this data suggest a doubling of these statistics in 2023 (Kaluarachchi, S., & Jayathilaka, R. (2024). These statistics illustrate that Sri Lanka continues to battle with the issue of brain drain, which is the exodus of skilled and talented persons from the country.

Additionally, the sentiment analysis that was carried out through our research shows evidence to show how the perspective of youngers in Sri Lanka on migratory goals. Basically, the sentiment analysis was carried out with a sample 75 young Sri Lankans' migratory perspectives reveals a general sense of dissatisfaction and frustration with the country's status. Economic hardship, political instability, and a perceived lack of opportunities all contribute to emotions of hopelessness and longing for change. Overall, most of them have a negative and agitated reaction about the current situation in Sri Lanka, and most of their intention was to migrate as soon as they could. These criticisms highlight the difficulties that young Sri Lankans have in seeing a flourishing future for their homeland.

The findings of sentiment research have substantial consequences, emphasizing the urgent need for policymakers and stakeholders to address the core causes of negative sentiment and discontent among adolescents.[6]By understanding the complex interplay of emotions, perceptions, and intentions driving migration decisions, policymakers can formulate targeted interventions aimed at fostering economic stability, creating job opportunities, and retaining talent within

Sri Lanka (Kurian & McHale, 2017). Sentiment study that was carried out provides useful insights into young Sri Lankans' migratory aspirations in the face of widespread negative emotions about the country's current condition. By addressing the underlying issues and providing suitable circumstances for youth development and involvement, Sri Lanka can seek to retain its talent and foster a brighter future for its young people.

C. Impact of migration on current Sri Lankan Situation

Migration has a huge impact on the socioeconomic landscape of Sri Lanka, influencing many areas of the country's growth trajectory. Understanding the multifaceted effects of migration on the current Sri Lankan situation necessitates a thorough examination of available material. Basically, it impacts the socioeconomic, political, and health landscapes of Sri Lanka.

- The impact on Economy

[7] Migration has both beneficial and negative economic consequences in Sri Lanka. On the one hand, remittances from overseas Sri Lankan workers contribute significantly to the country's foreign exchange reserves and household income (De Silva & Abeyratne, 2016). [8] However, the exodus of qualified professionals and labor force can cause workforce shortages, particularly in vital areas like healthcare and engineering, stifling economic growth and development (Wickramage et al., 2018).

- The impact on Social Implication

[9] Migration has a significant social impact on Sri Lanka, influencing families, communities, and societal dynamics. The departure of talented individuals frequently causes family breakdowns, strain on social support systems, and disruptions in community cohesion (Perera, 2015). [10] Furthermore, migration might increase gender

inequities by leaving women behind to maintain home tasks while male family members work abroad (Athukorala & Bartley, 2018).

- The Impact on Society

[11] Migration has a wide-ranging impact on Sri Lanka's health landscape. While migrant workers' remittances can improve household access to healthcare and healthcare-seeking behavior (Mahendra et al., 2019), [8] migration also poses health risks, such as exposure to infectious diseases, mental health issues, and insufficient access to healthcare services for migrants themselves (Wickramage et al., 2018).

- The Impact on Politics

[8] Migration has deep and multifaceted political repercussions in Sri Lanka. Brain drain can harm the country's potential for innovation, research, and governance when skilled workers seek opportunities overseas (Wickramage et al., 2018). [12]

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Furthermore, migration can shape political dynamics through diaspora engagement, remittance-based investments, and transnational political advocacy (Gamlen et al., 2013).

- The Impact on Policy Implication:

[8] Addressing the effects of migration on the current Sri Lankan scenario necessitates evidence-based policymaking and focused initiatives. Policies targeted at maximizing the developmental benefits of migration, such as fostering diaspora engagement, facilitating skill transfer, and enhancing social safety systems for left-behind families, can help reduce migration's negative repercussions (Wickramage et al., 2018).

Migration has a wide range of complex effects on Sri Lanka's current situation, affecting the nation's socioeconomic, political, and health environments. Comprehending these effects is crucial in devising efficacious policies and treatments that optimize the advantages of migration while mitigating its drawbacks.

D. Reasons behind migration intention of youngsters in Sri Lanka

Understanding the variables influencing young Sri Lankans' migratory intentions is critical for tackling the difficulties and opportunities presented by this demographic development. A literature review gives insights into the primary causes for migration intention, which are consistent with sentiment analysis findings that emphasize common concerns such as,

- 1) unstable economy
- 2) limited job opportunities
- 3) educational pursuits
- 4) perceived quality of life
- 5) political instability and governance concerns

- 1) Unstable economy

[13] Sri Lanka's economy has seen volatility and instability in recent years, with fluctuating growth rates, currency devaluation, and high inflation rates (Jayawardena, 2019). These economic issues erode trust in the country's prospects, leading young Sri Lankans to seek chances abroad where economic conditions may be more favorable.

2) Limited job opportunities

A lack of adequate work prospects, particularly in industries that match the abilities and aspirations of young Sri Lankans, is a primary driver of migration intention [14] Furthermore, low incomes in comparison to the cost of living reduce the appeal of staying in Sri Lanka for professional progress and financial security (Fernando & Gunawardana, 2018)

3) Education Pursuits

[6] Educational aspirations influence migration intentions among young Sri Lankans. Many people seek possibilities to pursue higher education abroad because of the perceived quality of education, research opportunities, and job progression options (Kurian & McHale, 2017). Furthermore, worries regarding the quality and accessibility of higher education in Sri Lanka motivate some people to seek educational opportunities abroad.

4) Perceived Quality of Life

[10] Young Sri Lankans' migration aspirations are influenced by their general quality of life, which includes elements like healthcare, infrastructure, safety, and governance. Perceptions of higher living standards and chances for personal and professional development overseas encourage people to consider migrating to improve their quality of life (Athukorala & Bartley, 2018).

5) Political Instability and Governance Concerns

Political instability, governance concerns, and perceptions of corruption all influence migration intentions by undermining trust in the government's ability to successfully manage socioeconomic challenges. Youth displeasure with the political climate and governance institutions may motivate them to seek chances in nations with more stable and transparent government systems.

Young Sri Lankans' migratory intentions are influenced by a complex interplay of economic, educational, social, and political factors. The sentiment analysis findings support prior literature, showing widespread concerns about the unstable economy, high inflation, restricted work possibilities, poor incomes, and educational

aspirations as main drivers of migration intention within this group.

III. METHODOLOGY

A. Data Collection and Preparation

First, data were collected by creating a detailed Microsoft Form specifically meant to investigate the "Exploration of Migration Intentions and Motivations among Sri Lankan Youth." This form was carefully designed to collect relevant data, including participant demographics, educational background (from elementary school to doctorate), countries of preference for migration, and the driving forces behind their desire to migrate. Through the distribution of this form to a broad range of people, required information was methodically gathered for the sentiment analysis.

As the second step Microsoft Form data is imported into Excel for more thorough analysis.

The screenshot displays the Microsoft Access 2010 interface. The ribbon at the top includes 'File', 'Home', 'Create', 'Database Tools', and 'View'. The 'Table Design' ribbon is selected, showing a grid of fields for a table named 'tblEmployee'. The fields are: 'EmployeeID' (Number, 10, Primary Key), 'LastName' (Text, 50), 'FirstName' (Text, 50), 'MiddleInitial' (Text, 10), 'Title' (Text, 50), and 'DepartmentID' (Number, 10, Foreign Key to 'tblDepartment'). The bottom status bar indicates 'Table Design View' and '1 of 1 records'.

This study explores the complex reasons why Sri Lankans choose to migrate, focusing on the act of leaving their native country. This study aims to investigate the upper age range of migrants and the complexities of their reasons for migrating. Our objective is to provide important insights into the complex processes of youth migration in Sri Lanka by revealing the social, educational, and aspirational elements that influence migration decisions through thorough study.

Fig 2: Data collection method

C. Further Analysis

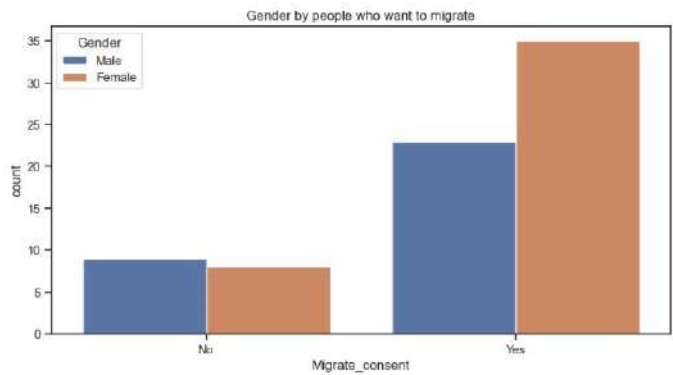


Fig 3: Gender by people who want to migrate.

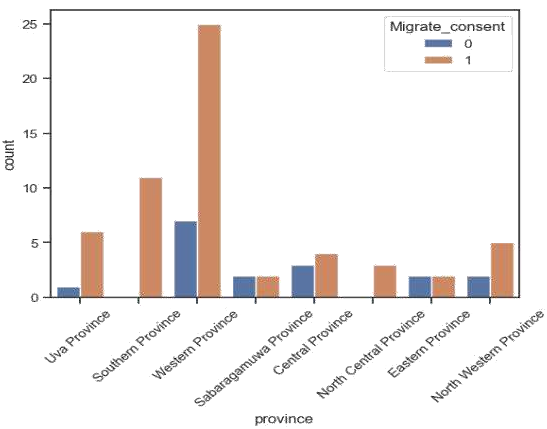


Fig 5: Count of people by their current regions and consent to

An analysis of the surveyed population's migratory intentions

shows a startling gender gap. Although a greater percentage of women than men indicate a wish to move, a greater proportion of women declare that they are committed to remaining in Sri Lanka than men. Males form the minority in both migration and retention decisions, highlighting a clear gender disparity in migration desires. These results highlight the need for customized interventions to address gender-specific migration trends and call for a sophisticated knowledge of gender dynamics in migration discourse.

migrate.

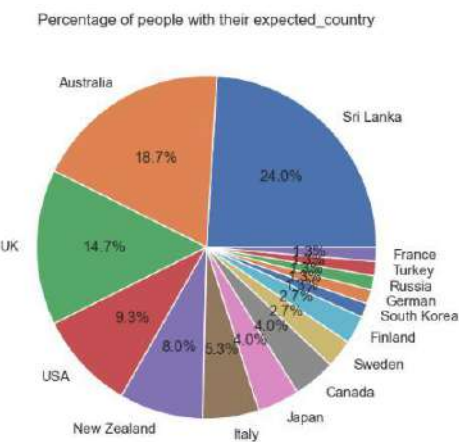


Fig 4: Percentage of people with their expected countries

The pie chart illustrates the preferred migration destinations among the youth demographic. It is clear from analysis that the total number of people who have indicated that they would like to move is more than the number of people who have stated that they would like to stay in Sri Lanka. This pattern highlights the population under study's general propensity for mobility. Although Australia is the most favored country, the combined attractiveness of the UK and USA indicates their considerable attraction outside of the Pacific. Additionally, the inclusion of Sri Lanka as a category clarifies the portion of respondents who do not have any desire to migrate, which adds to a thorough knowledge of migration preferences among the population group being studied.

Fig 6: Participants' migrating consent by their region (province)

The map of Sri Lanka depicts the distribution of young people's migration inclinations among provinces. Notably, the results show a clear trend in which the Western Province emerges as the main point of migration intention, outpacing other regions in terms of youth willingness to relocate.

Provinces with higher rates of urbanization have a larger tendency to migrate. This result is consistent with the belief that urban regions provide greater possibilities and amenities, which draws young people who are looking for affluent lifestyles. On the other hand, migration intention is relatively lower in rural regions, suggesting a desire for traditional lifestyles and a sense of local rootedness.

The Western Province's prominence in the debate around migration highlights its role as the center of economic activity and urban growth in Sri Lanka. This research highlights how urbanization shapes ambitions and patterns of spatial mobility, offering important insights into the socioeconomic factors influencing adolescent migration preferences.



Fig 7: Most frequently used words by participants

A key-word cloud analysis was performed using the Latent Dirichlet Allocation (LDA) methodology to identify and extract the important themes from the answers given by the participants of the survey about their reasons for migrating. The Word-Cloud image was used to depict the frequent words identified by the key-word analysis. Words like "opportunities," "future," "limited," and "abroad," which are the most frequently occurring terms in the dataset.

The word cloud analysis offers strong evidence that a variety of factors, such as the perception of a lack of opportunities, worries about one's future in the current economic environment, and a desire to pursue fulfillment overseas, influence young Sri Lankans' decision to migrate.

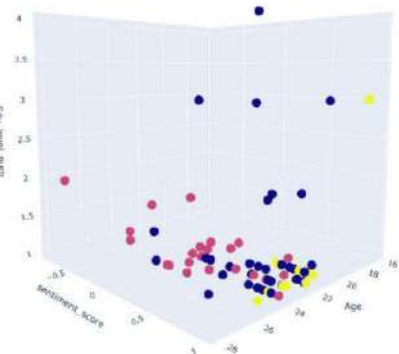
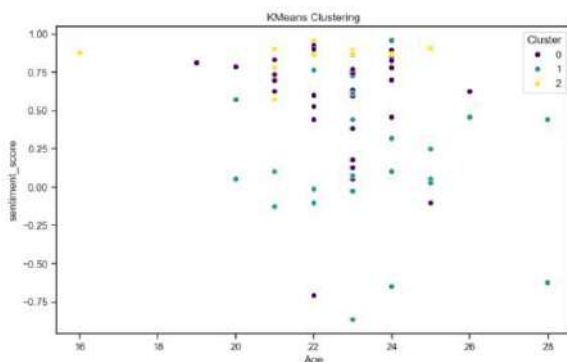
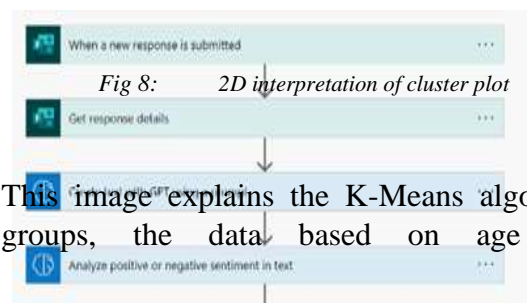


Fig 9: 3D interpretation of cluster plot

This is a 3D plot inspired by the previous 2D cluster plot, with a new column named "Educational level" as z labels representing the current educational status of participant who completed our survey by representing the Sri Lankan youth.

D. Process of the Overview

For this problem **Power Automate** and **Python** are the key to whole process, Microsoft Power Automate is a low-code development platform that enables customers to build custom automation flows without requiring considerable coding experience. Python, on the other hand, is a robust and the most popular platform that allows users to apply machine learning models and statistical actions. In this case, Microsoft Forms may be used to create a responsive system for people to submit migration questions, and Power Automate can automate the process of providing tailored responses depending on the supplied queries. Together, these tools improve procedures, increase efficiency, and allow informed decision-making.



This image explains the K-Means algorithm groups, the data based on age and

sentiment_score in this scenario. Based on the specified groupings, cluster 2 (shown in yellow) represents the youngers with a positive sentiment on their motherland. Cluster 1 in green represents bit elder people with a moderate intention about the country's status, whereas cluster 0 in purple represents younger people including adolescents with a well-distributed sentiment score about the Sri Lanka. Based on the findings, it can be assumed that people who are from cluster 0 have a higher tendency to migrate to another country in the future.

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Fig 10: flow of the process

When the system receives a new response submission, it retrieves its details. Using GPT, it generates an AI powered automated email depending on the given prompt, under the

supervision of the flow owner. The text's sentiment is then assessed to determine if it is positive or negative. An approval process is then launched to ensure that the resulting text is of high quality and relevant. A conditional check is conducted before proceeding. Finally, the system modifies a specific row to properly manage and organize the collected data. This streamlined procedure improves efficiency and allows for the systematic examination of migration intentions, which contributes vital insights to our research on maintaining talent in Sri Lanka.

E. Effectiveness of the Process

In the automated process, the mechanism monitors the progression and functionality of each phase, providing insight into response handling. Daily response influxes are examined to better understand engagement levels. Key parameters like median and average run durations provide an idea of efficiency. Action success rates and statuses provide information regarding process reliability. The flow version run count records iterations for enhancements. This complete analysis allows for continual optimization, resulting in smooth operation and informed decision-making in our research scenario. By studying these indicators, we acquire vital insights into the dynamics of migration intentions among Sri Lankan youth, which helps us improve our retention efforts.

The research uses Microsoft Power Automate to provide a streamlined procedure for understanding and addressing migration intentions among Sri Lankan adolescents. We provide educated insights to individuals while improving data management efficiency through automated response processing, sentiment analysis, and targeted feedback. This methodical approach improves our understanding of migration trends while also making it easier to build focused retention tactics. By maintaining talent in Sri Lanka, we catalyze socioeconomic development, so boosting the country's wealth and progress. This comprehensive solution emphasizes the importance

of technology-driven research in tackling real-world issues and encouraging long-term growth.

IV. FINDINGS

The findings of this study show fundamental causes influencing the migratory inclinations of Sri Lanka's youth demographic, with the goal of improving knowledge of the socioeconomic dynamics that drive migration within this population. The study uses sentiment analysis tools to understand young Sri Lankans' perceptions of opportunities within the country and attitudes toward migrating. The findings of this analysis have major consequences for policymakers, providing useful information for initiatives aiming at talent retention and socioeconomic growth in Sri Lanka.

These are the Key Findings that we have highlighted through our study.

A. Complex Motivations for Migration

The study indicates that young Sri Lankans' aspirations to migrate are impacted by a wide range of reasons beyond just financial gain. Economic prospects are important, but the urge to move is also largely driven by feelings of disillusionment coming from high young unemployment, a lack of professional chances, political unpredictability, and educational progress.

B. Sentiment Analysis Insights

A review of the opinions voiced by young Sri Lankans reveals a generalized discontent and annoyance with the country's current situation. A few young people consider migrating to seek change because of economic hardship, political unrest, and a sense of being left behind.

C. Impact of Migration on Sri Lanka

For Sri Lanka, migration has significant socioeconomic, political, and health effects. Although abroad workers' remittances boost household income and foreign exchange reserves, the flight of qualified professionals brings with it problems such changes in societal dynamics and a lack of labor.

D. Policy Implications

The results highlight how crucial it is to make decisions based on facts and implement focused interventions to address the root causes of migration and promote sustainable development in Sri Lanka. Policymakers may create programs targeted at promoting economic stability, opening job opportunities, and keeping talent in the nation by having a thorough grasp of the intricate interactions between the various factors that influence migration decisions.

V. RECOMMENDATIONS

The findings provide guidance for policymakers, stakeholders, and researchers working to solve the difficulties of youth migration and promote sustainable development in Sri Lanka. Based on the primary results and consequences stated in the research, the following recommendations are made,

A. Enhanced Economic Opportunities

Addressing the economic variables that drive migration is critical to retaining talent in Sri Lanka. Policymakers should prioritize providing jobs, promoting economic stability, and improving professional chances for young Sri Lankans. Initiatives like skill development programs, business support, and investment in critical industries can serve to reduce the attraction of migration for economic reasons.

B. Investment in Education and Healthcare

Increasing access to high-quality education and healthcare services is critical for retaining talent and promoting socioeconomic growth in Sri Lanka. Policymakers should prioritize investments in education infrastructure, curriculum improvement, and healthcare facilities to give young Sri Lankans with chances for personal and professional development within the country.

C. Technology-Driven Solutions:

The study emphasizes the efficacy of technology-driven approaches, such as Microsoft Power Apps and Power Automate, for speeding data collecting, analysis, and decision-making. Policymakers and researchers should use cutting-edge technologies to support data-driven policy responses, increase efficiency, and encourage informed decision-making while tackling migration concerns.

D. Evidence-Based Policy Formulation:

Policymakers should use sentiment analysis insights to help them develop evidence-based policies. Understanding the varied factors driving movement among Sri Lankan youth allows policymakers to implement targeted interventions that address the core causes of migration while also establishing conducive circumstances for talent retention.

E. Gender-Specific Interventions:

Given the research's findings of significant gender discrepancies in migration intentions, there is a need for gender-specific interventions in migration discourse. Policymakers should adjust their activities to meet the specific challenges and goals of both male and female adolescent populations, fostering gender equality and inclusivity in migration policies.

The study digs into the complex landscape of migration aspirations among Sri Lankan adolescents, using sentiment analysis as the primary tool. The study uses machine learning algorithms and sophisticated sentiment analysis techniques to uncover the underlying feelings and reasons that drive young Sri Lankans to consider migration. Its goal is to get a full understanding of the socioeconomic factors that influence migration decisions by evaluating textual data collected via questionnaires. The study examines not only the difficulties experienced by Sri Lankan emigrants, but also the appeal of specific countries as migration destinations. The goal is to give insights that will guide policy development and decision-making processes, with a special emphasis on reducing brain drain in Sri Lanka.

In conjunction with this research, the use of Microsoft Power Automate provides a more efficient technique to assessing and

VI. CONCLUSION

managing migration aspirations among Sri Lankan adolescents. By automating response processing, undertaking sentiment analysis, and offering tailored feedback, the study improves data management efficiency while presenting users with educated insights. This systematic approach not only helps us analyze migration trends, but it also makes it easier to build targeted retention tactics. By retaining talent in Sri Lanka, the research helps to catalyze socioeconomic development, which advances the country's wealth and advancement. Finally, this holistic solution demonstrates the transformative power of technology-driven research in tackling real-world difficulties and promoting long-term progress in Sri Lanka.

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Predicting Water Quality Conditions in Wimmera Catchment, Australia: A Machine Learning Approach Using Environmental Parameters

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Abstract— The research aims to determine the water quality condition of Wimmera catchment in Australia based on the different environmental parameters like temperature, turbidity, electrical conductivity, dissolved oxygen and hydrogen potentials (pH). A quantitative approach on the data set extracted from the Australian government data repository was used in the study and machine learning algorithms such as Clustering, Gradient boosting and Random Forest algorithms were used based on the nature of the data set. The regimes of water flow were predicted based on the different environmental parameters throughout the sampling locations in the Wimmera catchment.

Key words—Water quality conditions, Environmental parameters, Regimes of flow, Clustering, Gradient boosting, Random Forest algorithm

Introduction

Water quality is a critical factor in maintaining the health and sustainability of aquatic ecosystems [1], as well as ensuring the safety and well-being of human populations that rely on these water bodies for various purposes [2]. In the context of Australia, the Wimmera catchment consisting 3% of Murray-Darling Basin which is one of the land locked rivers [3],

where it provides water resources that are essential for agricultural, industrial, and domestic activities, understanding and predicting water quality is of paramount importance. It appears that water, that is colorless and transparent is safe for human Consumption. This could not always be the case because a lot of the bacteria and undesirable material might be present in water resources. For the efficient management and preservation of aquatic ecosystems, especially in dynamic situations with varying flow regimes like No flow, Low flow, and medium flow of water reservoirs, the water quality prediction is essential. Even though water quality is an important topic to be discussed, despite its importance, many existing studies have relatively less address regarding the water prediction with respect to its impact on human use, aquatic habitats and agriculture. This study aims to fill this gap by developing a predictive model that uses environmental parameters to forecast water quality in Wimmera Catchment within the Murray-Darling Basin in Australia. The goal of this study is to provide the insights on early detection of potential issues such as pollution, salinity and dissolved oxygen

levels, thereby supporting as a study that provides insights on which proactive interventions to be taken with regard to sustainable water quality measurement that is to be used in present and to preserve for the future generations.

Water Quality Measurement

Water is essential to the life cycles of all living and non-living ecologies, yet because of its endless use and waste, water seems to be becoming scarcer. Water pollution is another area where critical attention must be put into but it is not a problem that arose recently, gradual population growth, drainage disposal, sewage disposal, waste fluids, acidic substance discharge, microbial contamination are some of the causes for the pollution of water resources [4]. Precautions to preserve the water resources are a growing concern worldwide. As a result, many researches were conducted with this regard in measuring the quality of the water resources to investigate whether the water resources are favorable for the environment, aquatic life and human use.

Environmental Parameters for water quality measurement

Different quality measures can be used when checking the purity and quality of water resources. There are variety of parameters that can be used for this purpose; physical, chemical and biological, environmental parameters [5], in this research we consider the environmental parameters such as electrical conductivity (EC), Dissolved Oxygen (DO), Turbidity (TURB), Temperature (TEMP), and Hydrogen Potentials (pH) for the measurement of water quality in Australian water resource bodies [6].

Electrical Conductivity (EC), is the water's measure to conduct electric current. It explains whether the water consists of dissolved ions, potential salinity issues and contamination that would be harmful for the environment, aquatic eco-system as well as human consumption.

Dissolved oxygen (DO), is the water's level of oxygen saturation, where it plays a vital role of preserving the aquatic life in water resources.

Turbidity (Turb), haziness or cloudiness of water that resulted due vast amount of invisible to the naked eye

or maybe small visible particles that enter the water bodies. Turbidity occurs due to causes such as soil erosion, run off from construction sites, agricultural activities, natural disasters like storms, urban development etc.

Temperature (Temp), water's thermal energy measurement. One of the crucial environmental parameters that measured in-order to investigate the physical and chemical processes in aquatic environment. Measured mostly in degrees of Celsius (°C) or Fahrenheit (°F).

Hydrogen Potentials (pH), is the acidity or the alkalinity of water that shows the quantification of hydrogen ions present in water. This parameter is measured in a logarithmic scale where pH value 7 is considered neutral, pH value greater than 7 is considered to be acidic and pH value below 7 is considered to be alkaline (normal).

Machine Learning Approach

Data collection to train a built model and test run are included as parts of machine learning approach. In this research, the data related to the water quality collected based on the environmental parameters of Wimmera catchment of Australia [3] will be evaluated in order to get more meaningful information and a prediction on the water quality measurement.

For the study purpose, algorithms were chosen according to the dataset, dataset feature importance and in general terms to identify groups of similar variables to get clear idea of what type of prediction could be given from this study. The selected algorithms were Clustering, random forest classifier, performance matrix and the Gradient Boosting algorithm for the model accuracy.

PROBLEM STATEMENT

Australia's Wimmera Catchment is an important area for water supplies, supporting aquatic habitats and human consumption. For sustainable management and conservation initiatives, it is crucial to comprehend and predict water quality measures. Measurement of water quality will give the safety of consuming this water reservoir for human activities, aquatic habitat and also favorable for environment for both present and future reference in making predictions on the quality of water. The problem

addressed in this study is to provide a predictive model that can forecast the water flow of the wimmera catchment using environmental parameters, and investigate whether this water reservoir's water supply is favorable for the aquatic life, human consumption and agriculture by leveraging the gap of previous studies with our study on providing predictive model that supports the sustainable water management.

THE OBJECTIVES OF THIS STUDY

The main objectives of this research are:

- i. To develop and validate a predictive model that can accurately forecast different flow regimes in the Wimmera Catchment when provided with environmental parameters, using machine learning techniques.
- ii. To assess the impact of the predicted water quality and regime flow on human health, agricultural productivity, and aquatic ecosystems, while identifying critical parameters that could indicate risk factors.
- iii. To assess the effectiveness of the machine learning model in identifying critical environmental parameters that influence water quality under varying flow regimes.

METHODOLOGY

This research aims to use a Quantitative approach to predict the water quality of Wimmera catchment in Australia using the essential environmental parameters, such as Electrical Conductivity (EC), Dissolved Oxygen (DO), Turbidity (Turb), Temperature (Temp), Hydrogen Potentials (pH) [6] that are being considered when measuring the water quality of this water reservoir.

The dataset chosen for this study was taken from Australian data repository [3], where it shows the water resource sites and the relevant data marked up as a dataset comprised of the years from 2003 to 2023. The dataset consists of a total of 4130 records

inclusive of the column headers. Missing values were present in the dataset, which explains the dataset selected to be an imbalanced dataset.

The parameters used for the study EC, DO, Turb, Temp, pH have their own specifications since these are main parameters used when water quality measurement apart from pH value being the most known parameter for this task.

In the dataset specific column named as "Condition" comprised of the different types of water flows that depicts the nature of water flow in 23 sites at wimmera catchment [3]. Condition types depicted in the dataset explains the various flows in the reservoir.



Fig. 1. Wimmera water quality site map



Fig.2 close up of the Wimmera Catchment

Fig.2 depicts the close view of the Wimmera catchment where the sampling was done to gather information for the data set to determine the water quality based on the different environmental parameters.

K-Means Clustering Algorithm

This is a type of unsupervised machine learning algorithm [7] used on data analysis where issue resolution is predicated on the algorithm's expertise using previously solved problems as a training schedule. The input of this technique is identified as not labeled. The Clustering algorithm used for this study explains which conditions are grouped

according to the relevant value input of the parameters, Electrical Conductivity (EC) and Hydrogen Potentials (pH). Since the parameters used as feature variables are of numerical format and the target variable that is the condition column is of categorical format, before the model training it was encoded and converted to numerical format since it is not acceptable in clustering. Through this method it allows the model to identify the patterns and groups of similar water quality conditions, making it easier to identify how different environmental parameters influence on the water conditions in the Wimmera Catchment.

Gradient Boosting Algorithm

This algorithm is versatile and a widely used algorithm in various datasets in order to improve the accuracy [8] of the predictive model and very much likely to be used when working with imbalanced datasets. This method is used for both structured data as well as to play a major role with handling datasets with missing values. This method also enhances the accuracy of the model by incrementally correcting the prior model errors. When it comes to water quality, this method helps to handle complex, non-linear relationships between environmental parameters which makes it easier to understand water quality fluctuations across different flow regimes in the Wimmera Catchment.

Random Forest Classifier

This is a machine learning algorithm used for both classification and regression tasks [9] where, multiple decision trees' predictions are combined to create the Random Forest classifier to get the final desired output based on the target variable determined using the given dataset. For this study on water quality measurement, Random Forest helps to identify the most important factors that influence the overall

water quality in Wimmera Catchment, where it reduces the overfitting and provides a stable model for predicting the water condition based on the used environmental parameters.

FINDINGS

The clustering algorithm was used in order to identify the optimal number of clusters that could be generated based on the environmental parameters using the water flow conditions. For this task Elbow method was used to determine the number of clusters in the clustering model.

Elbow Method

When doing clustering analysis, particularly K-means clustering, the "elbow method" is a methodology that can be used to help figure out the ideal number of clusters for a sample of data. Plotting the sum of squared distances (SSD) or the within-cluster sum of squares against the number of clusters is the method's main step. The K-means algorithm is run for a range of values of k (number of clusters). The "elbow" in the plot denotes the point at which the rate of SSD reduction begins to slow down, meaning that the performance of the model is not considerably enhanced by adding more clusters.

The elbow plot in this study denotes the point where the inertia where it starts to slowly decrease showing the optimal number of clusters for the given dataset.

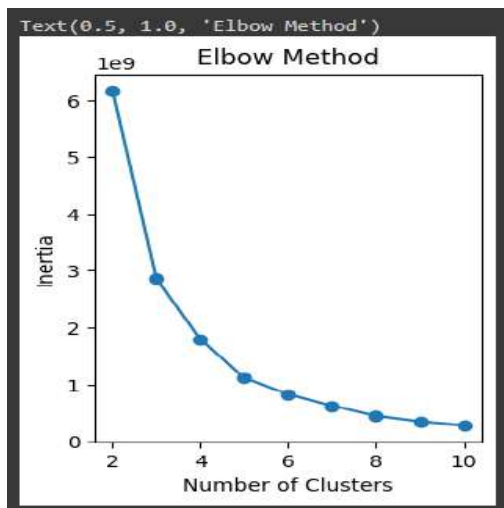


Fig.3. Elbow graph for clustering

In Fig. 3, it depicts that using elbow method, the number of clusters appears to be 4, since from that point it starts to decrease slowly showing that it is the optimal number of clusters when using that method.

Accordingly, once these clusters are being fit to the model it gives the number of clusters that are being clustered based on the water flow condition. As Clustering is a method used to identify similarities and the patterns, in the practical scenario of water quality measurement, where different water flow conditions show distinct environmental parameters making it easier to monitor and assess water quality based on flow types. For Instance, when the water quality is in low-flow condition, it may show high turbidity and lower dissolved oxygen, which can negatively impact on the aquatic life [5].

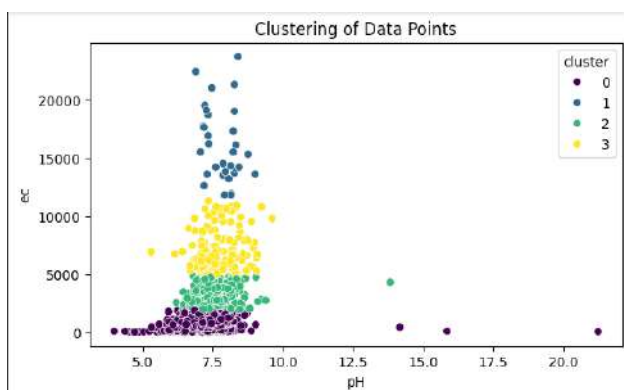


Fig. 5. Clusters based on the data points and the water flow condition.

The below figure will show the clusters characteristics in a tabular format.

	ec	turb	temp	ph
cluster				
0	829.910039	46.756851	15.325639	7.271969
1	16050.000000	96.028125	14.691250	7.845313
2	3014.704974	43.500395	15.483894	7.541887
3	6712.275132	66.092593	15.840529	7.723968

Fig. 6. Cluster Characteristics based on the each parameter.

For further understanding the separate graphical visualizations were generated for each cluster based on the specific parameter used, that is Ph and EC values.

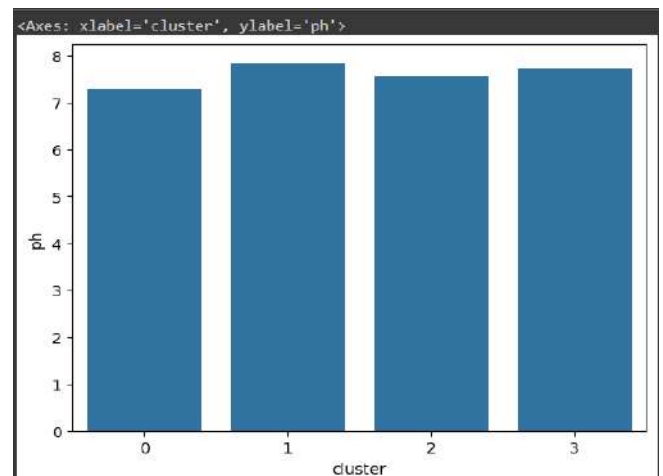


Fig. 7. Clusters variation on pH value parameter

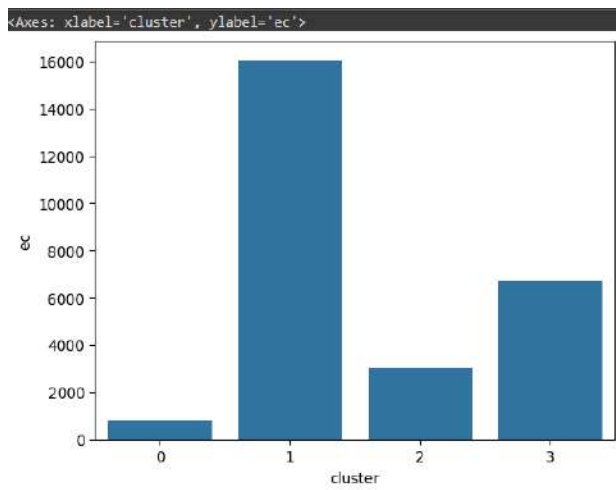


Fig. 8. Cluster variation on EC value parameter

Gradient Boosting algorithm

The Gradient Boosting is used because of its highly effectiveness in predictive modeling, particularly dealing with imbalanced datasets. It enhances the model accuracy by correcting the errors made by the prior models. In this study of studying the water quality measurement, the model accuracy, precision, recall and the F1-score was generated where it helps to improve the accuracy of environmental parameters used for this study.

A good accuracy range could be considered as being above 80% for many tasks. A good F1 score varies depending on the task and dataset, but generally, a score above 0.7 or 0.8 is considered good. A precision score above 0.7 or 0.8 is considered good, but again, the acceptable range can vary depending on the specific task and context. A good recall score indicates that the model captures a high proportion of positive instances. Similar to precision, a recall score above 0.7 or 0.8 is generally considered good.

According to our findings the model accuracy shows of 74.5% for predictions where F1 Scores, Recall and Precision values indicated a favorable model that

reliably predicts the water quality. Accordingly, this model can also be allowed for early detection of water quality of water quality conditions of the Wimmera Catchment. For an instance, if the model predicts that pH or dissolved oxygen levels are likely to drop below safe levels, preventive measures can be taken [4] to protect both aquatic ecosystems and human water consumption.

TABLE I. MODEL ACCURACY

PREDICT ED VALUES	PERCENTAGE %			
	ACCURA CY	PRECISIO N	RECALL	F1-SCORE
GRADIEN T BOOST RESULTS	0.7475935	0.91647648	0.9410434723	0.9101597182

Random Forest Classifier

The Random Forest is a powerful machine learning algorithm that is used in this study provides insights on the importance of different environmental parameters in predicting water quality. The respective feature importance calculated using a Random Forest Classifier for the water quality dataset is as follows:

Parameters	Percentage%
	Values
Electrical Conductivity	0.226106
Dissolved Oxygen	0.196893
Turbidity	0.198320
Temperature	0.197284
Hydrogen Potentials	0.181397

According to the output values of the random forest algorithm, it clearly shows that the Electrical Conductivity (EC) and Turbidity (Turb) were the significant

environmental parameters influencing the water quality in the Wimmera Catchment, followed by Temperature (Temp), Dissolved Oxygen (DO) and Hydrogen Potential (pH). This finding plays a critical role as it can be used as a suggestive measure [2] for the researchers or any users to focus more on EC and Turb parameters to make effective and reliable assessments of water quality, leading to more effective water management.

For a better understanding, the below figure shows the graphical representation of the feature importance of the dataset.

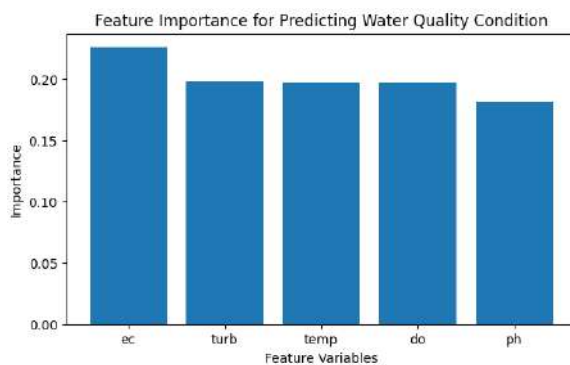


Fig. 9. Feature importance in graphical format

Below shows the outcome of the trained model that predicts the water flow condition based on the input parameter values to the model. Through our study we aimed to provide a predictive model that predicts the water flow types in regimes in the Wimmera Catchment. This model study could also be a driving force for the researchers and users to make deeper and more advanced model development on water quality predictions, more deeper understanding on the other environmental parameter that may have direct or indirect impact on the water quality conditions that may not limit to the Wimmera Catchment within the Murray-Darling Basin in Australia.

```

# Assuming new_data is a DataFrame containing the new data entities with columns
# ec, do, turb, temp, ph
new_data = pd.DataFrame({
    'ec': [4030],
    'turb': [15.4],
    'do': [9.8],
    'temp': [16.2],
    'ph': [7.41]
})

# Use the trained model to predict the condition for the new data entities
predicted_condition = clf.predict(new_data)
print("Predicted Condition:", predicted_condition)

Predicted Condition: ['No Flow (Pooled)']

```

Fig. 10. Final prediction on the trained model.

Predicting water quality offers numerous advantages for aquatic ecosystems and human populations. For aquatic ecosystems, real time water quality predictions help in maintaining biodiversity by ensuring optimal levels of environmental parameters which are critical for the survival of Aquatic organisms. Early detection of pollutants or drastic changes in water parameters allows timely interventions to prevents the degradations of the habitats. Whereas for Human populations, accurate water quality predictions are very much crucial to sure safe drinking water and sanitation. By monitoring changes in the water quality, one can take the necessary preventive actions, reducing the risk of waterborne diseases and ensuring the continuous supply of clean water. For agriculture, as it is one of the most important sectors that is specialized in cultivation, need water quality predictions which is crucial for efficient irrigation. Polluted water or water with high levels of salinity or turbidity can harm crops, reduce crop yields and make a significant negative impact on the overall agricultural sector if not maintained with efficient and sustainable water measurement and management.

LIMITATIONS OF THE STUDY

The limitations noted throughout our study are as follows: Geographical Specificity, where the model built for the water quality measurement for specific regions in the Wimmera Catchment in Murray-Darling Basin, may often fail to generalize well to

other locations due to differences in environmental and climatic conditions. Another limitation can be noted as the model accuracy, where in our study, the model's accuracy resulted in a favorable value, yet there can be more influential factors that may have not been in the target parameters and water flows which are not in our research.

conclusion

The current study emphasizes the water quality condition on the different regimes of flow through the Wimmera catchment within the Murray-Darling Basin located in Australia which provides water to the native communities in Australia for all the irrigation, agricultural, aquatic habitat and human usage purposes in the area. The study conducted, used data based on environmental factors and machine learning algorithms were used for predicting the outcome of the water flow condition based in the parameters. The different regimes of water flow depending on the environmental parameters were predicted in the different sites located in the Wimmera catchment using the machine learning algorithms.

future works

The future research based on water quality should focus on developing the model to predict the water quality condition more efficiently to identify poor environmental parameters that negatively affect the water bodies and how the natural ecosystems can be preserved in favorable for human consumption, agricultural purposes and as well as the aquatic habitats.

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A Comprehensive Analysis of the Surge in Lithium Battery-Related Fires with leveraging machine learning

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Abstract— This research paper explores the increasing surge in lithium battery-related fires, particularly those involving electric vehicles (EVs) and lithium-ion batteries, presents a pressing safety concern that demands urgent attention. While EVs are lauded for their potential to significantly reduce carbon emissions and support sustainable transportation, the growing occurrence of battery fires underscores significant risks to public safety. This research provides a comprehensive analysis of the surge in lithium battery-related fires, with a specific focus on EVs and lithium-ion batteries. Through the utilization of classification, clustering, and data visualization methodologies, the study aims to identify underlying techniques, the study seeks to uncover underlying

patterns and emerging trends linked to incidents. Furthermore, the research investigates the effectiveness of existing safety measures and protocols in mitigating fire risks, while also proposing evidence-based recommendations for enhancing fire prevention, emergency response, and public awareness initiatives.

Keywords—Lithium battery-related fires, Electric Vehicles (EVs), Lithium-ion batteries, Sustainable transportation, clustering, classification.

I. INTRODUCTION

Lithium-ion batteries have become a cornerstone technology in various industries, particularly in the automotive sector where they power Electric Vehicles (EVs). In the last years, concerns were voiced with respect to the fire safety of vehicles powered by new

energy carriers, primarily battery electric vehicles [1]. With increasing concerns about climate change and the push towards sustainability, EVs have gained significant traction as an alternative to traditional gasoline-powered vehicles. Lithium-ion batteries offer several advantages over conventional fuel sources, including lower greenhouse gas emissions, reduced dependence on fossil fuels, and potentially lower operating costs. The adoption of lithium battery vehicles, particularly Electric Vehicles (EVs), has been steadily increasing worldwide. In general, the European Union and its member states have committed to a binding target to the reduction of greenhouse gases (GHG) of at least 40% by the year 2030 as compared to 1990 [2]. To achieve this goal, recently, the European Union has announced several policies towards emission standards for land vehicles starting from the year 2020. The standards include emission target for new cars

which is at 95 gCO₂/km, target of 90% reduction in transport greenhouse gases (GHG) emissions by 2040, and projection of 13 million zero- and low- emission vehicles by 2025. On top of this, several countries in Europe have announced their own policies towards promoting electric vehicle deployment. As a result of the supportive policies along with rapid technological advances for EVs, the global EV stock has increased by an annual average of 60% between the year 2014 and 2019 [3].

Many vehicles fire each year may therefore pose a risk of significant cumulative emission, especially for the more persistent compounds [4]. As highlighted by the London Fire Commissioner, fires involving lithium batteries are emerging as the fastest-growing fire risk in the city. This surge in incidents necessitates a comprehensive analysis to identify underlying factors, trends, and mitigation strategies.

A. Overview of Lithium Battery- related fires and their impact.

This research aims to provide a thorough investigation into the surge of lithium battery-related fires, with a specific focus on incidents involving electric vehicles and lithium-ion batteries. Identify key risk factors associated with electric vehicles and lithium-ion batteries, including battery management systems, charging infrastructure, and regulatory compliance. Propose evidence-based recommendations and best practices for fire prevention, emergency response protocols, and public awareness campaigns to mitigate the risks posed by lithium battery- related fires [2]. By conducting a comprehensive analysis of the surge in lithium battery-related fires, this research aims to provide valuable insights for policymakers, urban planners, emergency responders, and the public to enhance fire safety measures and ensure the sustainable integration of electric vehicles and lithium-ion batteries into urban environments like London.

Single-vehicle fires can be considered as relatively small events compared to, for example, fires in buildings with the rapid adoption of electric vehicles (EVs) and the widespread use of lithium-ion batteries in various consumer electronics and industrial applications, understanding and mitigating the risks associated with these energy storage systems have become paramount [3].

B. Comparative Analysis of International EV Policies

The government's policy and regulatory framework concerning the transition to electric vehicles (EVs) and the phase-out of fossil fuel vehicles reflect a multi-faceted approach aimed at addressing pressing environmental and economic concerns. With objectives centered on reducing carbon emissions, enhancing air quality, and fostering economic growth through green technologies, the legislative measures put forth by the government form the cornerstone of this initiative. Key among these measures is the zero-emission vehicle (ZEV) mandate, which mandates that a significant percentage of new cars and vans sold in Great Britain must be zero-emission by specified deadlines, ultimately culminating in a complete transition to electric by 2035[3].

The timeline and targets established by the government serve as clear indicators of its commitment to accelerating the adoption of EVs. By requiring 80% of new cars and 70% of new vans to be zero-emission by 2030, with the remaining vehicles to follow suit by 2035, the UK sets itself apart as a global leader in the transition to electric mobility. This trajectory aligns the nation's goals with those of other major economies like France, Germany, Sweden, and Canada, signaling a collective commitment to combatting climate change and embracing sustainable transportation solutions.

As evidenced by the latest industry figures, which indicate that 20% of new cars sold in August were zero-emission, and the existence of over 48,100 public charge points across the country, the government's efforts are yielding tangible results. Moreover, with more than £2 billion in government investment dedicated to phasing out fossil fuel vehicles and supporting the transition to EVs, the UK is well-positioned to continue making strides towards its ambitious targets. Through a combination of proactive policy measures, strategic investments, and collaborative efforts with industry stakeholders, the government remains steadfast in its commitment to realizing a greener, more sustainable future for transportation in Great Britain.

ensuring the safe and sustainable integration of EVs and lithium-ion batteries into our communities.

II. PROBLEM STATEMENT

The surge in lithium battery-related fires, particularly those involving electric vehicles (EVs) and lithium-ion batteries, presents a pressing safety concern that demands urgent attention. Despite the promising benefits of EVs in reducing carbon emissions and promoting sustainable transportation, incidents of battery fires pose significant risks to public safety, property, and the environment. With the rapid adoption of EVs and the widespread use of lithium-ion batteries across various sectors, understanding the root causes and mitigating factors associated with these fires is paramount. Additionally, the complex interplay of factors such as battery management systems, charging infrastructure, regulatory compliance, and public awareness further complicates efforts to address this issue effectively.

Therefore, there is an urgent need for comprehensive research to identify key risk factors, trends, and mitigation strategies to enhance fire safety measures, emergency response protocols, and public awareness campaigns. By addressing these challenges, policymakers, urban planners, emergency responders, and the public can collaboratively work towards

III. THE OBJECTIVES OF THE STUDY
The main objectives of this study are:

- I. Characterize Patterns: Analyze historical data to identify recurring patterns and trends in lithium battery-related fires involving electric vehicles (EVs) and lithium-ion batteries. This involves examining factors such as frequency, severity, location, and time of occurrence to gain insights into the nature of these incidents.
- II. Identify Contributing Factors: Investigate the specific technical, environmental, and operational factors that contribute to the increasing occurrence of fires in EVs and lithium-ion batteries. This includes assessing aspects such as battery design, manufacturing defects, charging practices, environmental conditions, and vehicle operation.
- III. Assess Safety Measures: Evaluate the effectiveness of existing safety measures and protocols implemented for lithium batteries, particularly within the context of EVs. This involves identifying potential gaps or areas for improvement in battery management systems, thermal management systems, charging infrastructure, and regulatory compliance.
- IV. Enhance Public Awareness: Contribute to public awareness and education efforts regarding the safe use and handling of lithium batteries, with a specific focus on EVs. This includes raising awareness about the risks associated with lithium battery-related fires, providing guidance on safe charging practices, and promoting the importance of adhering to manufacturer recommendations and regulatory guidelines.

IV. METHODOLOGY

In this research, a methodology centered around classification, clustering, and data visualization to comprehensively analyze the surge in lithium battery-related fires was used with a specific focus on incidents involving Electrical Vehicles (EVs) and lithium-ion batteries in London.

By combining these methodological approaches, this study aims to provide a comprehensive and understandable analysis of the surge in lithium battery-related fires in London, offering valuable insights for the London Fire Brigade and other relevant authorities to enhance fire safety measures, emergency response protocols, and public awareness campaigns in the city.

A. Clustering

Clustering, a fundamental technique in data analysis, aims to partition a dataset into groups or clusters based on the similarity of data points within each group. One of the most widely used clustering methods is the k-means algorithm, which partitions the data into k clusters by minimizing the within-cluster variance. [5] K-means iteratively assigns data points to

the nearest cluster centroid and updates the centroids until convergence, making it efficient for large datasets. However, a limitation of k-means is its reliance on Euclidean distance, which is suitable only for numerical data, and it may struggle with categorical or mixed data types.

To address this limitation, the k-mode algorithm has gained prominence, particularly for datasets with categorical or mixed data types. [6] Unlike k-means, which operates on numerical data, k-mode is specifically designed to handle categorical attributes. It defines dissimilarity between data points based on mode dissimilarity measures, which are more appropriate for categorical data. K-mode clustering aims to find centroids that represent the modes of each cluster, effectively grouping similar data points with categorical attributes into clusters.

In our research, given the heterogeneous nature of the dataset comprising mixed data types, we opted for the k-mode clustering algorithm. [6] By leveraging the strengths of k-mode clustering, we aimed to effectively group similar data points with categorical attributes into clusters, thereby facilitating subsequent analysis and interpretation. Furthermore, the utilization of k-mode clustering aligns with the characteristics of our dataset, enabling us to uncover meaningful patterns and insights that may not be evident with other clustering methods.

B. Classification

Classification algorithms serve as essential tools in research methodology, aiming to effectively categorize data into distinct classes based on input features [7]. Random forest classifiers, a prominent example of ensemble-based learning methods, offer simplicity, speed, and remarkable success across diverse domains [8]. During training, random forests employ bagging on individual trees to mitigate overfitting, a common challenge in decision trees, thus enhancing model accuracy [8]. Leveraging Random Forest in research methodology, particularly in predicting fire incidents linked to lithium batteries, proves invaluable. By analyzing various features like ignition sources, power-related factors, vehicle details, and geographical data, this algorithm yields precise predictions and valuable insights into the factors underlying such incidents.

V. EXPERIMENTAL EVALUATION

A. Case Study

In recent years, fires involving lithium batteries have emerged as the fastest-growing fire risk in London, posing significant challenges to public safety and emergency response efforts. To better understand and address this pressing issue, a comprehensive case study analysis was conducted, focusing on incidents involving Electrical Vehicle (EV) and lithium-ion batteries from Calendar Year 2017 onwards. The dataset, provided by the London Fire Commissioner, offers a detailed breakdown of these incidents, including information on the frequency, severity, and specific circumstances surrounding each fire. By examining trends, patterns, and contributing factors within this dataset, researchers gained valuable insights into the dynamics of lithium battery-related fires in an urban setting like London.

Furthermore, the case study provided a foundation for identifying areas of concern, assessing the effectiveness of existing safety measures and protocols, and formulating evidence-based recommendations for enhancing fire prevention, emergency response, and public awareness initiatives. Through this research, stakeholders including policymakers, urban planners,

emergency responders, and the public can collaborate to develop targeted strategies

aimed at mitigating the risks posed by lithium battery-related fires and ensuring the continued safety and resilience of London's communities.

B. Safety Considerations in Lithium Battery Electric Vehicles: Analysis of Fire Risks and Mitigation Strategies

Table 1 provides a breakdown of the types of incidents involving lithium battery-related fires, along with the corresponding counts for each type. The incidents are categorized into various types of vehicles or devices that utilize lithium batteries.

From electric bicycles and cars to scooters, buses, and even agricultural vehicles, the data underscores the widespread adoption of lithium battery technology across various sectors. Moreover, the inclusion of less common categories such as e-cigarettes and motor homes indicate the broad spectrum of devices susceptible to lithium battery fires. This summary provides valuable insights into the potential risks associated with lithium batteries in different vehicle types, emphasizing the importance of effective safety measures and regulatory oversight to mitigate these risks.

TABLE I. BREAKDOWN OF LITHIUM BATTERY-RELATED FIRES BY VEHICLE TYPE

Type of vehicle or device	Totals	
	Index	Count
E-Bike	14	321
Car	3	292
Other lithium battery	9	231
E-Scooter	16	111
Bus / Coach	2	48
Other road vehicle	10	42
E-Cigarette	15	35
Van	13	32
Motorcycle	7	16
Lorry/HGV	4	15
Multiple Vehicles	8	10
Motor Home	6	5
Towing caravan	11	1
Trailer	12	1
Bicycle	1	1
Minibus	5	1
Agricultural Vehicle	0	1

Fig. 1. Illustrates the distribution of lithium battery-related fire incidents across different vehicle types associated with fires in London.

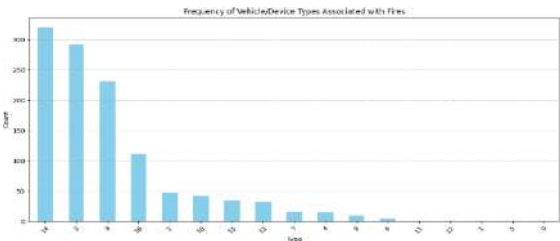


Fig. 1. Frequency of vehicle or device types associated with fires

To visually represent this information, a bar chart has been created to show the frequency of different vehicle/device types associated with fires. This visualization provides a clear overview of the distribution of incidents across various types, aiding in identifying patterns and potential areas of concern.

C. Impact of Lithium Battery Usage on Incidents in Vehicle Clusters

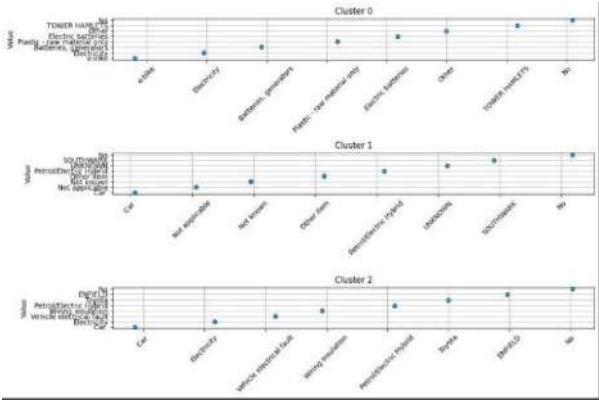


Fig.2. Clustering analysis

Fig.2. depicting first the **Electric Bike Incidents in TowerHamlets**. The first cluster derived from the k-mode clustering algorithm reveals a pattern of incidents primarily involving electric bikes (e-bikes) powered by electricity and electric batteries. These incidents, concentrated in Tower Hamlets, often result in the combustion of plastic or raw materials, with ignition sources mainly attributed to batteries and generators. Notably, there is a lack of mentions of lithium batteries in these incident reports.

Second the **Hybrid Car Incidents in Southwark**.

Cluster two highlights a series of incidents involving hybrid cars, particularly petrol/electric hybrids. However, details regarding ignition sources and initial materials ignited are not well-documented in this cluster. The incidents predominantly occur in Southwark, with the manufacturer of the vehicles involved remaining unidentified. Like Cluster 1, there is no mention of lithium batteries in the incident reports within this cluster.

D. Predictive Modeling for Lithium Battery-Related Fire Incidents in Electric Vehicles

Including the column "Lithium batteries mentioned in report?" as a feature among the columns in our dataset is a crucial step in building a predictive model. This column serves as the target variable or label for our classification task.

Toyota Hybrid Car Electrical Faults in Enfield: The third cluster primarily comprises incidents involving Toyota petrol/electric hybrid cars, with Enfield being the predominant location. These incidents are characterized by electrical faults within the vehicles, leading to the ignition of wiring insulation material. Despite the specific manufacturer and location patterns,

there is no mention of lithium batteries in the incident reports within this cluster.

The clustering results provide valuable insights into distinct subsets of incidents with specific characteristics related to vehicle types, power sources, ignition sources, and geographic locations. Further investigation is warranted to understand the root causes of incidents within each cluster, identify common patterns or trends, and devise preventive measures tailored to each subset. Comparative analysis with incidents from other regions or involving different vehicle manufacturers could enhance understanding and facilitate targeted safety improvements.

E. Predictive Modeling for Lithium Battery-Related Fire Incidents in Electric Vehicles

Fig.3. depicts a line chart is a graphical representation of data that shows how a particular quantity changes over time. In recent years, the surge in lithium battery-powered vehicles, particularly electric vehicles (EVs), has significantly altered the landscape of transportation, promising cleaner, and more sustainable mobility solutions. However, as the adoption of lithium battery technology has accelerated, so too have concerns regarding safety, particularly in relation to fire incidents. This phenomenon underscores the importance of understanding and mitigating the risks associated with lithium battery-powered vehicles. The current situation reflects a growing need for comprehensive analysis and proactive measures to address these safety concerns. Despite advancements in lithium battery technology and vehicle design, incidents involving lithium battery related fires have continued to occur, prompting a critical examination of contributing factors and risk factors. Factors such as battery design, manufacturing processes, charging infrastructure, and vehicle maintenance practices all play crucial roles in determining the safety and reliability of lithium battery-powered vehicles.

across different classes. The classification performance metrics for each class are as follows: Class 0 (representing the class labeled as 0): Precision = 0.93, Recall = 0.86, F1-score = 0.89 Class 1

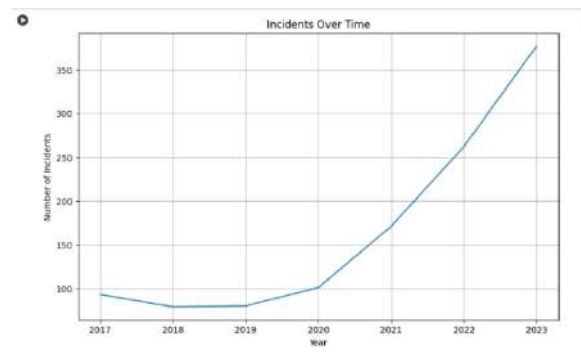


Fig.3. Incidents over time

Interpreting the results obtained from the classification task, it is evident that the Random Forest Classifier model performed well in predicting incidents involving lithium battery-related fires. The model achieved an accuracy of 0.86, indicating that it correctly classified 86% of the instances in the dataset. Additionally, precision, recall, and F1-score metrics were analyzed, providing further insights into the model's performance

(representing the class labeled as 1): Precision = 0.76, Recall = 0.88, F1-score = 0.81 These metrics provide insights into the effectiveness of the classification model in correctly identifying instances of each class. A higher precision indicates fewer false positives, while a higher recall indicates fewer false negatives. The F1-score provides a balanced measure of the model's performance by considering both precision and recall.

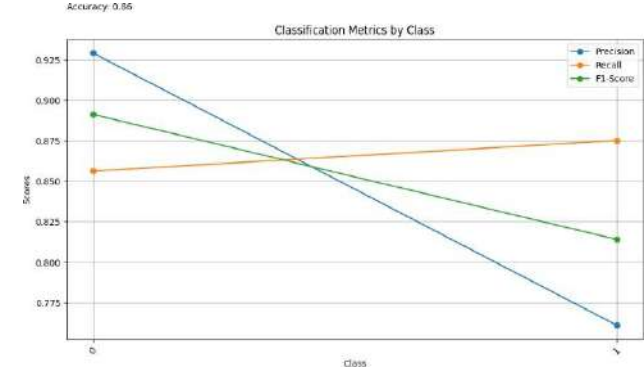


Fig. 4. Classification Metrics by class.

This chart illustrates classification metrics such as precision, recall, and F1-score for each class in a classification problem, offering a visual comparison of performance across classes. Additionally, the plot includes accuracy and enables interpretation of strengths and weaknesses for individual classes, facilitating a comparative analysis of metrics to identify class-specific patterns. The classification task holds significant implications for fire safety and public policy, as it enables the identification of high risk areas and the implementation of targeted interventions to mitigate the risk of lithium battery-related fires. Challenges may include imbalanced datasets, noisy data, or overfitting, which can impact the model's performance and reliability. Solutions may involve data augmentation techniques, feature engineering, or hyperparameter tuning to improve model robustness.

F. Interpreting Correlation Coefficients in understanding Strength, Direction, and Significance

The correlation matrix is a $(K \times K)$ square and symmetrical matrix whose ij entry is the correlation between the columns i and j of X . Large values in this matrix indicate serious collinearity between the variables involved [8]. -1 indicates a perfectly negative linear correlation between two variables. 0 indicates no linear correlation between two variables. 1 indicates a perfectly positive linear correlation between two variables. The further away the correlation coefficient is from zero, the stronger the relationship between the two variables.

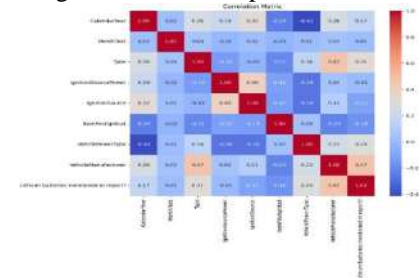


Fig.5. Correlation Matrix
Fig.5. depicts a correlation matrix provides a structured representation of the pairwise correlations between variables in a dataset. Each cell in the matrix contains the correlation coefficient, which quantifies the strength and direction of the linear relationship between two variables. Correlation matrices are often visualized as heatmaps, where the cells are color-coded based on the correlation coefficient. This provides a visual representation of the strength and direction of the correlations, making it easier to interpret the relationships between variables.

G. Exploring Multivariate Relationships Using Pair plots

Exploratory Data Analysis (EDA). EDA is the process of figuring out what the data can tell us, and we use EDA to find patterns, relationships, or anomalies to inform our subsequent analysis. While there are an almost overwhelming number of methods to use in EDA, one of the most effective starting tools is the pairs plot (also called a scatterplot matrix). A pairs plot allows us to see both distribution of single variables and relationships between two variables [9]. The below pair plot is typically used to visualize relationships between different features in a dataset. It generates a grid of scatterplots where each feature is compared to every other feature, and histograms along the diagonal to show the distribution of each individual feature.

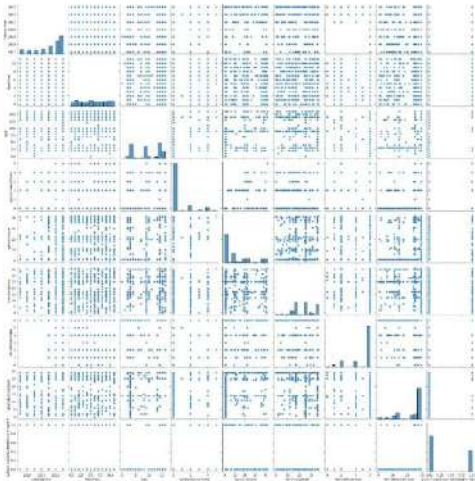


Fig.6. Pair plot to visualize relationships between different features.

Pair plots are more commonly used in exploratory data analysis (EDA) to understand the relationships and distributions within the data. While they can provide insights into the data structure, they are not directly related to classification or clustering tasks.

H. Spatial Distribution Analysis of London Boroughs: Informing Based on Regional Categorization

Table 2 provides a categorization of London boroughs based on their respective regions. This categorization facilitates the analysis of borough distribution across different parts of the city. Urban planners, researchers, and policymakers can use this information to inform decisions related to infrastructure development, demographic analysis, and targeted interventions within specific regions of London.

Table II. Categorization of London Boroughs by Region

Region	Boroughs
East London	Barking And Dagenham, Newham, Redbridge, Havering
West London	Hounslow, Hammersmith, and Fulham, Richmond Upon Thames, Kensington, and Chelsea, Richmond Upon Thames, Ealing, Harrow
North London	Islington, Barnet, Enfield, Islington, Haringey
South London	Greenwich, Bexley, Lambeth, Greenwich, Bromley, Lambeth
Central London	Westminster, Camden, City of London

I. Injuries and Fatalities Summary: Analyzing IncidentData for Safety Insights

emission by 2035, providing clarity to manufacturers while safeguarding UK jobs with other major global economies, including France, Germany, Sweden, and Canada [10].

VII. FUTURE WORKS

In the future, research aims to delve deeper into predictive modeling techniques to anticipate and mitigate lithium battery related fires in London. By leveraging machine learning algorithms, we seek to identify complex patterns and trends within the data, enabling the development of robust predictive models. Additionally, efforts will be directed towards enhancing public awareness and education regarding the safe handling and usage of lithium batteries, particularly in the context of electric vehicles. Explore additional features or data sources to enhance the

Fig.7. presents a line chart showing the trends of NumFireDeaths and NumAllFireInjuries over time. The data includes information on Calendar Year, NumFireDeaths, and NumAllFireInjuries. The mean number of fire deaths is approximately 0.86, with a standard deviation of 1.46. The mean number of all fire injuries is around 37.29, with a standard deviation of 33.57. This line chart illustrates the trend of fire incidents over the years from 2017 to 2023. The blue line represents the number of fire deaths, showing a gradual increase over time, with slight fluctuations. The red line represents the total number of fire injuries, displaying a more fluctuating pattern with a peak in 2022. Overall, the chart provides insights into the trends and fluctuations in fire incidents, including both fatalities and injuries, over the specified period.

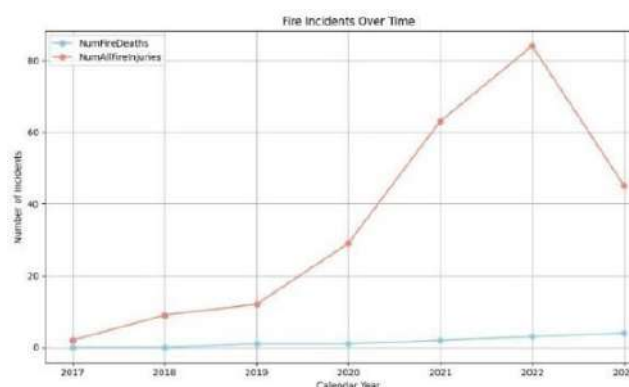


Fig.7. Fire incidents over time.

VI. CONCLUSION

This study emphasizes the analysis of the dataset on lithium battery-related fires in London underscores the urgent need for proactive measures to address this growing fire risk. The data highlights the prevalence of incidents involving electric vehicles and lithium-ion batteries, emphasizing the importance of understanding the contributing factors and implementing targeted interventions. By integrating advanced analytical techniques with proactive safety measures, we can work towards ensuring the sustainable integration of lithium battery technology while safeguarding public safety and well-being in London and beyond. Government sets out path for all new cars to be zero

classification model's performance and reliability.

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The Use of Code-Switching as a Teaching Tool at the Tertiary Level: A
Case Study of English Lecturers in the Department of English Language
Teaching at the University of Kelaniya

Abstract— *The present study examines the use of Code-Switching (CS) as a teaching tool by English lecturers in the Department of English Language Teaching (DELT) at the University of Kelaniya. The research focuses on compulsory 2-credit intensive courses including English for Humanities (DELT 12252) and English for Social Sciences (DELT 11212), which are offered to undergraduates from the Faculty of Humanities and the Faculty of Social Sciences. The key objective of this study is to determine the frequency and rationale behind the use of CS by DELT lecturers during English as a Second Language (ESL) lectures. Qualitative data for the study were gathered from 12 temporary assistant lecturers and demonstrators of the DELT via semi-structured interviews. Data were analyzed thematically using Canagarajah's (1995) theoretical framework on the functions of CS. The findings denote that CS is strategically used by DELT lecturers to enhance instructional effectiveness, particularly in contexts that require improved student comprehension and active engagement. This study further identifies the most and the least common reasons for the use of CS by lecturers, demonstrating its role in facilitating better comprehension and engagement among undergraduates. This research contributes to the broader understanding of the pedagogical benefits of CS in bilingual educational settings, emphasizing its significance in improving English language instruction at the tertiary-level education system in Sri Lanka. Further, this study evinces that CS facilitates better comprehension and engagement among undergraduates. Overall, the findings conclude that while CS is an effective teaching tool during ESL lectures, its application remains context-dependent.*

Keywords: *Code-Switching, Teaching Tool, English Language Teaching*

I. INTRODUCTION

Code Switching (CS) is a common linguistic phenomenon among bilingual and multilingual speakers, occurring when a speaker alternates between two or more language varieties within a single conversation. According to Nunan and Carter (2001), CS is a phenomenon of switching from one language to another in the same discourse. The use of more than

one language in a conversation is a common phenomenon among bilingual and multilingual speakers (Bot, Lowie and Verspoor, 2005). Due to the development of modern societies, interethnic communication and the spread of globalization, the use of CS has become widespread (Munawaroh et al., 2022). In regions where bilingualism and multilingualism are common, CS is a routine feature of daily communication, often deemed unremarkable yet distinctive of bilingual behavior (Wei and Martin, 2009). According to Holmes (2001), the mastery of more than one language encourages people to use CS in various contexts and is one of the significant fields in educational contexts. Sri Lanka, shaped by centuries of migration and colonialism, is a multicultural and multilingual nation where English serves as the 'link language', while Sinhala and Tamil are retained as official languages under the 13th Amendment to the Constitution. English, in Sri Lanka, has a visible presence (Karunaratne, 2009) in society, as it is the language learned by many Sri Lankans as their second language (L2) (Udagama, 1999). Consequently, CS is frequent in Sri Lankan educational settings, from primary to tertiary levels. In ESL or EFL (English as a Foreign Language) classes with students from diverse linguistic backgrounds, CS is extensively observed (Cahyani, 2018). This suggests that multilingual or bilingual individuals often switch languages easily in everyday interactions and within ESL classroom contexts. Cook (2013) and Timor (2012) emphasize that incorporating the first language (L1) into activities can facilitate the teaching of a second or foreign language, highlighting the pedagogical value of CS in language learning environments. In the Sri Lankan education system, students in government schools study in either Sinhala or Tamil mediums, with English offered as a secondary language. Bilingual education from grade 6 was established by circular No.05/2007 (NIE, 2007), designating English as the second language in the curriculum and the link language of the country as per the 13th Amendment to the Constitution. English remains a compulsory subject at the General Certificate of Education (Ordinary Level) (G.C.E. O/L), with the bilingual policy extending to Grades 10 and 11. However, the University Admission Handbook (2020), published by the University Grants Commission (UGC), indicates that General English is not mandatory for entry into main degree programs such as Engineering,

Medicine, Management and Arts. Nevertheless, for specific courses, an O/L English Credit pass (C) or an A/L General English Simple pass (S) is required. For instance, eligibility for a special degree in Law (Course Code- 025) requires at least a Credit pass (C) in English at the G.C.E O/L or a Simple (S) pass at the G.C.E A/L Examination. At the tertiary level, all government universities have expanded and strengthened their English Language Teaching Units (ELTU) or DELT by improving the curriculum, human resources and capacities (University Student Charter, 2012, p. 20). While extensive research highlights the prevalence and the pedagogical value of CS in ESL classrooms, there is a lack of empirical studies focusing on its use as a teaching tool by English lecturers at the tertiary level in Sri Lanka.

II. METHODOLOGY AND EXPERIMENTAL DESIGN

This qualitative study investigates English lecturers' use of CS at the DELT of the University of Kelaniya, focusing on two research questions: "Do English lecturers utilize code-switching as a teaching tool during their ESL lectures?" and "What are their beliefs and attitudes towards the use of code-switching during English lectures?". The theoretical framework is based on Canagarajah's (1995) micro and macro functions of CS, categorizing micro-functions into classroom management (e.g: regulating interactions, managing discipline) and content transmission (e.g: explanations, translations). It examines how CS facilitates classroom interactions, including opening classes, requesting help and negotiating cultural relevance among English lecturers and undergraduates. Data were collected through semi-structured interviews with twelve, BA (English) or BA (Hons) TESL graduates who work as demonstrators and assistant lecturers at the DELT and conduct English lectures (English for Humanities - DELT 12252 and English for Social Sciences- DELT 11212) for the undergraduates from the Faculty of Humanities and the Faculty of Social Sciences. The study was conducted with the necessary permissions obtained from the assistant lecturers and demonstrators at the DELT of the University of Kelaniya. Eleven female lecturers and one male lecturer participated and the interviews were conducted via telephone. Each interview lasted 15-20 minutes and was recorded and later transcribed. Thematic analysis was used to analyze the responses, addressing lecturers' perceptions of CS and its functions during the English lectures. This approach assures a comprehensive understanding of the lecturers' use and rationale for CS during their lectures.

III. RESULTS AND DISCUSSION

Ten interview questions were used to thematically analyze the attitudes and beliefs of twelve lecturers. The basic themes can be identified as follows,

1. Personal experiences.
2. The use of CS.
3. Perceptions and beliefs regarding the use of CS.
4. Influence of social environment.
5. English lecturers' encouragement to use English.
6. English lecturers' personal experiences regarding the reasons for students' CS.
7. Advantages and disadvantages of using CS in ESL classrooms.

1. Personal experiences

Six respondents strongly agreed that CS contributed to making a comfortable learning environment and easier communication, especially for undergraduates who are struggling with ESL. They emphasized that CS supports when clarifying complex grammar concepts and instructions, making learning more accessible and inclusive by using students' familiar languages like Sinhala or Tamil alongside English (Respondents 2, 3, 4, 6, 8 and 9). In contrast, three respondents emphasized the context-dependent nature of CS, suggesting its effectiveness varies and according to them, it depends on the proficiency levels of the students. Al-Marzouki and Albeyali (2024) demonstrated in their study that a majority of EFL lecturers from Digital Colleges and Yanbu Industrial College in Saudi Arabia strongly affirmed that CS serves mainly repetitive functions such as providing instructions, translation, linguistic competence and comprehension. Therefore, they believed that CS constitutes a distinctive linguistic necessity within the realm of higher education. While highlighting its utility in certain scenarios, three respondents also highlighted the importance of not overusing CS, promoting instead a balanced method that emphasizes English language immersion and proficiency development (Respondents 7, 9 and 12). Another four respondents pointed out the importance of minimizing the use of CS in language classrooms. They denoted that while CS can be a useful classroom tool, it should not hinder other pedagogical strategies aimed at improving English language learning. They emphasized the importance of selecting appropriate teaching methods and making student-centered learning activities and authentic materials to support the language acquisition of students without completely depending on CS (Respondents 1, 3, 6 and 9). Overall, the responses from the lecturers reflected various perspectives on the role of CS in ESL instruction. Some think CS is essential for diminishing language barriers and creating student-centered learning contexts. Others warn against using it too much, suggesting a balanced approach that combines CS benefits with broader educational goals in language teaching. This distinctiveness highlights

the ongoing arguments regarding the use of effective strategies or tools for supporting language learners in multilingual educational contexts in Sri Lanka.

2. The Use of CS

The third interview question, "when do you typically utilize Sinhala during a lecture?" received varied responses. Nine respondents stated that they use CS primarily to explain complex grammar concepts or to re-explain difficult sections when requested by lower-level students (Respondents 2, 3, 4, 6, 7, 8, 9, 10 and 12). When there are some points that need emphasis, lecturers or professors use CS whether consciously or unconsciously to convey them effectively and properly (Bairmani et al., 2022). CS is also used to ensure student comprehension, address unresponsiveness, elicit concepts and break the monotony during the lectures. According to Lin (2013) and Jingxia (2010), CS is utilized to foster a tight interaction between teachers and pupils. As a result, professors and lecturers like to use CS when aiming to build rapport and foster a sense of connection with their students, as it helps students feel more relaxed and at ease.

Moreover, three respondents indicated that *"we utilize Sinhala when students struggle with comprehension, as it helps to build a positive and supportive rapport. Additionally, employing Sinhala allows us to share our academic-related experiences that impart valuable life lessons to students. Sometimes, we would switch to Sinhala to crack a joke or short story to enliven the atmosphere of our lectures"* (Respondents 1, 5 and 7). In ESL or EFL classrooms, English indexes a more distanced, formal (or institutional) teacher-student relationship and the local native language. To build rapport with individual students, foster interpersonal affinity and encourage greater learner involvement, a teacher or instructor may strategically employ CS when the occasion is appropriate (Adendorff, 1993; Canagarajah, 1995; Lin, 1996). One respondent noted the rare use of CS, except to communicate with introverted students. The use of CS by lecturers significantly reduces students' exposure to the target language (TL). Thus, it is explicit that lecturers employ CS to clarify complex topics, ensure comprehension and build rapport with students. While CS creates a supportive learning environment, overuse may hinder TL exposure. In ESL/EFL contexts, maintaining a balance between CS and TL immersion is crucial for language acquisition.

3. Perceptions and beliefs regarding the use of CS

The beliefs and attitudes regarding the use of CS are the basis of question No.05 and question No.06. The responses revealed both positive and negative attitudes towards CS, yet the majority of academics (approximately 75%) feel that the usage of CS in ESL or EFL lecture contexts has a detrimental impact on

students' acquisition of the TL. According to many scholars, the use of CS in ESL classrooms negatively affects the TL acquisition of the learners (Rao, 2013; Sert, 2005; Ellis, 2008). Elias et al. (2022) discussed concerns that CS could lead to over-reliance on the L1, potentially hindering students' proficiency development in the TL. This reliance may reduce opportunities for L2 immersion, ultimately slowing language acquisition. Instructors and teachers in ESL or EFL contexts have, overall, been concerned about minimizing CS in the classroom, taking it that the switches either indicate a failure to learn the TL or an unwillingness to do so (Yao, 2011). This negative perspective was highlighted by ten respondents who agreed with the fact that CS leads to improper language use among young students. They asserted that to achieve proficiency in a particular language, students should exclusively use that language, especially the TL, without mixing it with other languages. These respondents emphasized that frequent use of CS during instruction ignites an expectation among students that the lecturer will always switch languages to aid comprehension. This dependency on CS can prevent students from making independent efforts to understand the material and adapt to the use of English, often leading them to think in their L1 before using L2. Thus, their L2 development will be drastically affected by this. Furthermore, it is believed that the regular use of CS by lecturers during formal language instruction may unintentionally encourage students to depend on lecturers for explanations of TL vocabulary and expressions in the students' L1. This occurs because when students are given alternatives, they tend to choose the easier option; either relying on the lecturer to code-switch or using CS themselves rather than attempting to construct meaning in the TL by using their existing linguistic repertoire. According to these respondents, the use of CS should be restricted to elucidating particularly challenging concepts and not employed consistently in the ESL classroom, as overuse of CS can lead to improper language use and adversely affect the language acquisition process (Respondents 1, 2, 4, 5, 6, 7, 8, 9, 10 and 11). However, three respondents suggested that CS is essential when instructing students who fall within the UTEL Benchmark band 5 or below, particularly when providing instructions (Respondents 3, 4 and 12). Thus, many respondents believe that CS is beneficial when teaching students with lower English proficiency levels, as these students find it difficult to comprehend all instructions given in English. In contrast, two respondents disagreed with the notion that CS leads to improper language use among undergraduates. They highlighted that CS fosters better rapport with students and encourages them to use the L2. As one respondent observed, *"I partially disagree with this point. Based on my personal experiences, CS builds a stronger bond with students,*

which in turn encourages them to use the L2” (Respondents 1 and 10). In sum, it is explicit that English lecturers should determine the academic level of the group of undergraduates that they are teaching and use CS when necessary to meet the demands of the students. The sixth question, “Do you think that CS will result in the overuse and overdependence on the undergraduates’ L1? If yes, why? If not, please indicate 2 reasons,” elicited predominantly negative responses. Most respondents expressed concerns that CS contributes to overdependence on students’ L1 (Respondents 1, 2, 4, 5, 6, 8, 9 and 11). One respondent remarked, “yes, when CS is used during lectures, students begin to expect definitions in their L1 every time.” Another added, “yes, I have personally observed that many undergraduates from the Faculty of Humanities rely more on CS when they struggle to express something in the TL. Therefore, students do not get the opportunity to learn how to express specific ideas instead, they bypass this learning by relying on CS and if the lecturer overuses it, this inevitably becomes an issue”. However, four respondents implied CS as an effective tool by explaining, “if we do not allow CS during lectures, students may struggle to acquire the content knowledge being taught, which can lead to decreased motivation to learn; thus, CS is often considered a remedial measure to address this risk. Additionally, the overuse and over-dependence on L1 can be mitigated through effective guidance and the planned and appropriate use of CS when necessary” (Respondents 2, 6, 7 and 9). The study reveals mixed perceptions and beliefs among lecturers regarding the use of CS. Many respondents identify CS as a potential hindrance to TL acquisition, particularly when overused, as it can lead students to rely excessively on their L1 and hinder their TL development. However, some respondents recognize the pragmatic value of CS, especially for students with lower English proficiency. These responses ultimately recommend a balanced approach to the use of CS highlighting English lecturers should assess their students’ linguistic proficiency and use CS selectively to improve comprehension and engagement without compromising TL acquisition. By doing that, lecturers can leverage the benefits of CS while minimizing its potential shortcomings, creating a more effective and supportive learning environment.

4. Influence of social environment

The seventh interview question concerns the impact of social background on students’ use of CS as it is a common phenomenon in our society and this language behavior is pervasive in daily interactions among students and their families. “So, do you think the social background influences the use of CS among undergraduates?” This question too drew both positive and negative responses. Five respondents

affirmed that the multicultural environment in Sri Lanka fosters CS in daily communication. Undergraduates who are influenced by their family and friends often pick up the habit of CS. Some students speak English at home, while others use only Sinhala or Tamil. This tendency to code-switch has become deeply ingrained in society, occurring naturally rather than as a deliberate choice (Respondents 2, 6, 9, 10 and 12). Individuals often code-switch spontaneously without premeditating their language use. It is more of an instinctive and spontaneous interaction embedded within society. In this context, bilinguals, particularly ESL learners, often switch to another code when they encounter other bilinguals from the same ethnic or social background. Bilinguals will switch to an ethnic code to express their identification with the group members (Trisnawati, 2017) even though they are not very proficient (Holmes, 2008). Thus, it is evident that the majority of undergraduates are influenced by their social background. CS is commonly used by ESL/EFL learners and lecturers in universities to demonstrate their education and intelligence. This practice reflects their ability to incorporate English into their speech (Masna, 2020). The trend of standardizing Sri Lankan English further normalizes CS in daily conversations and ESL lecture contexts. Additionally, undergraduates from the Faculty of Humanities, whose degree programs are primarily conducted in their L1 (Sinhala), experience limited exposure to the TL during DELT lectures. The primary language of instruction throughout their academic journey remains their L1, restricting opportunities for engagement with the TL. Contradictorily, degree programs under the Faculty of Social Sciences are taught in English, resulting in minimal use of CS among these students. However, some respondents challenged the view that social background is the sole factor influencing CS (Respondents 1, 5, and 7). One respondent denoted, “while some students belong to families where English is not spoken at home, others are part of families that use English to signal social status and encourage its use among their children.” Nevertheless, social background alone cannot be regarded as the only cause of CS. Other factors, such as the students’ motivation to learn English, the frequency with which they practice the language and their level of comprehension, also significantly contribute to the occurrence of CS.

5. Lecturers’ encouragement to use English

The encouragement of English lecturers to use English during lectures was addressed via the fifth interview question and all the respondents answered positively. According to the respondents, “we first take on the role of a close friend to the students. Then, we gradually encourage them to actively participate in English lectures by instilling confidence in their

abilities to speak and utilize the language without hesitation or fear". This approach emphasizes the importance of building rapport and trust with students, which in turn facilitates a learner-friendly environment. CS is also used to reduce students' affective filters such as anxiety, fear and demotivation, aligning with Krashen's Affective Filter Hypothesis (1985), which posits that lowering the affective filter is crucial for successful language acquisition. One respondent explained, *"I encourage students to speak in English during explanations. I initiate conversations about their day or familiar topics to create a comfortable environment, then stress the importance of using English. I also reassure them that making mistakes is part of the process, as it is not their mother tongue."* This approach includes allowing students to ask and answer questions in English, encouraging peer interactions in English and providing feedback at the end of each activity. The respondents also incorporate a variety of real-time activities to motivate students to use English by enhancing their language proficiency.

6. Lecturers' experiences regarding the reasons for the use of CS by the students

Based on their personal experiences, four respondents addressed this query explaining that students frequently resort to CS due to limited knowledge, inadequate language skills or lack of confidence in expressing themselves in English (Respondents 3, 5, 8 and 9). Skiba (2012) argued that one of the factors accounting for CS is the students' inability to express themselves and get their message communicated in language classrooms and CS contributes to maintaining the continuity of speech and it does not interfere with the flow of linguistic expression. When students are not well-versed in vocabulary and English grammar rules, they tend to use CS. Additionally, students use CS to converse better or to help fit into their friends' circles even during lecture contexts. CS is a technique preferred by students when discussing personal issues in ESL classrooms (Orynbeek et al., 2020). Another function of CS is to communicate ideas more effectively when speaking. As stated by Nerghes (2011, as cited in Mukti and Muljani, 2016) bilingual speakers consider the notion that when associated with strong arguments CS can be an effective strategy in which some ideas can be better conveyed in one language than another that leads to systematic processing of information. Furthermore, CS helps avoid misunderstandings and clarify important information that cannot be explained in one language or code. Some bilingual speakers including students tend to code-switch when they encounter lexical gaps in the TL, using their L1 to express terms or ideas that lack an appropriate counterpart (Eldin, 2014). Overall, the main reasons for the students' use of CS include a lack of proficiency in the L2, ignorance of English, the

simplicity of speaking in one's L1, drawing attention, pragmatic considerations, filling in gaps in speech, conveying intimacy, averting misunderstandings, emphasizing points and maintaining privacy. Thus, CS is a prevalent technique among bilingual students, reflecting various underlying factors and pragmatic needs.

7. Advantages and disadvantages of using CS in ESL classrooms

The use of CS in ESL lecture contexts evokes both advantages and disadvantages, as articulated by respondents based on their experiences and perceptions. As advantages, they identified how CS helps to improve class participation by inducing a relaxed lecture atmosphere that allows students to perform much better. According to Metila (2009), CS helps to improve class participation by inducing a relaxed class atmosphere that allows students to perform much better. Abad (2005) contends with Metila (2009) that CS manages to lower the effective filter and this consequently builds rapport and creates an atmosphere of informality in the classroom between the instructors/ teachers and students aiding in a more democratic and critical learning environment for the students. In the same vein, many of the respondents highlighted the fact that effective use of CS and how it helps students with a lower proficiency level in English and how it makes a learner-friendly environment (Respondents 1, 2, 4, 5, 6, 9, 10 and 11). This approach was seen as particularly beneficial for students with lower English proficiency, facilitating their understanding and engagement in lessons (Selamat, 2014). Lee (2006) in his research affirms that the discourse (CS) used by the students outside the classroom should be allowed inside the classroom discussion process because it helps the students contribute to the discussion process and bridges any social and cultural gap. Moreover, the use of CS not only facilitates the smooth flow of communication but also creates a more interactive and live classroom environment, encouraging student participation (Adendorff, 1996). This factor has been proven by Perego and Boyle (2013) stating that L1 facilitates both teaching and learning such as confidence, security, motivation and friendship. The use of L1 in ESL/ EFL classrooms gives students a more comfortable setting in which they can speak freely with no strict rules of English-only policy. One respondent stated, *"I believe CS plays a crucial role in assisting students with language learning. It is unrealistic to expect them to speak in English when they lack even basic vocabulary. Therefore, CS is necessary initially to guide them through their zone of proximal development."* By using CS as a scaffold, educators can support students in reaching this phase, aligning with Krashen's (1985) input hypothesis. Thus, it is evident that proper implementation of CS fosters a supportive and relaxed classroom

environment, assists students with lower English proficiency and promotes improved communication and participation, thereby contributing to a more effective and engaging educational experience.

However, in the same vein, the lecturers' negative attitudes regarding the use of CS can also be identified. Some respondents argued that excessive reliance on CS may hinder students' fluency in the TL. Consequently, six respondents indicated that because the content of English lectures is presented in English, students are expected to communicate in English and CS should be kept to a minimum. According to them, *"lecturers who work with young students should employ CS as the final alternative after all other efforts to teach TL have been exhausted"* (Respondents 1, 3, 5, 9, 11 and 12). Another respondent highlighted her negative response to the use of CS during lectures pointing out one of the arguments made by Krashen (1985). According to Krashen (1985), the maximum exposure to the L2 should be increased and lessons should be conducted in the TL as far as possible. Krashen (1985) argued that the use of the L1 would detract from L2 learning. Moreover, according to three respondents, *"switching between L1 and the TL during a lecture will result in a decline in the standards of English"* (Respondents 4, 10 and 11). This concern was proven by Wei and Martin (2009) stating that the practice of CS in the ESL classroom is a contentious issue in the field of Second Language Acquisition (SLA) because it is believed to result in unacceptable language use among students. Moreover, another respondent identified the specific challenge of grammatical interference between L1 and L2, noting that overreliance on CS can negatively affect sentence structure. In the case of Sinhala and English, the grammatical structures differ significantly, with Sinhala following a subject-object-verb (SOV) structure and English adhering to a subject-verb-object (SVO) agreement. As a result, when students code-switch, they may transfer the syntactic patterns of their L1 into English leading to grammatical errors. This suggests that while CS can provide initial support in language learning, excessive use may create dependency, impeding students' ability to internalize and apply the correct grammatical rules of the TL. Another negative response emphasized that in language classrooms, lecturers should prioritize the development of receptive and productive skills. However, if students lack consistent exposure to English or do not actively participate in English communication during lectures, their speaking and listening skills are unlikely to progress effectively. This lack of exposure and practice hinders their overall language proficiency development. In general, none of the respondents rejected the use of CS. Instead, they should decide when L1 needs to be used in order to enable comprehension and meaningful

involvement of learners. As denoted, lecturers' use of CS during English lectures implies that CS is either used consciously or unconsciously by them. Furthermore, as English lecturers, they need to consider the long-term effect of using CS which might affect the students' SLA process while interacting with the native speakers of the TL. In this aspect, CS may act as a barrier that limits the full visibility of either language. Where two languages are well developed, then bilingualism is more likely to lead to cognitive advantages than disadvantages (Baker, 1995). Thus, improving proficiency in both languages can enhance cognitive flexibility and overall language ability, reducing the potential drawbacks of CS.

III. CONCLUSION & RECOMMENDATIONS

This current study reveals that CS has much value in accelerating SLA, especially when it is utilized with purpose and situational awareness. The qualitative data analysis suggests that the majority of the lecturers identify CS as an effective teaching tool, yet it depends on the situation where they use it. CS is predominantly used for specialization and clarification purposes, aimed at elucidating complex concepts encountered by undergraduates. The most common reason for lecturers' minimal use of CS is linguistic competence as they are specialists in language teaching. Regardless of the specific reasons for its deployment, CS consistently contributes to effective knowledge transfer and comprehension enhancement among students. The theoretical framework of the study encompassing Canagarajah's functions of code-switching (1995), including both macro and micro functions, can be generalized as lecturers predominantly use CS for micro functions to open lectures energetically, provide clear definitions and explanations, give commands, deliver instruction and manage mitigations and compliments effectively. Simultaneously, Canagarajah's macro functions are pivotal in bridging cultural gaps, supporting institutional objectives and enhancing pedagogical flexibility, thereby accommodating the diverse linguistic and cultural contexts of students in Sri Lankan higher education settings. In conclusion, the results of the study provide a strong notion that CS can effectively be used as one of the crucial educational tools in tertiary-level education contexts in Sri Lanka. By recognizing its multifaceted functions and employing it fruitfully, lecturers can enhance effective pedagogy and student engagement. Hence, it is explicit that CS can be employed effectively not only to support language learning but also to enrich the overall educational experience, nurturing a more comprehensive and interactive learning environment in higher education contexts in Sri Lanka. This study explores the use of CS during English lectures and future research could broaden the scope to examine additional dimensions of this

phenomenon. Future research could first explore the issue from the perspective of ESL undergraduates in Sri Lanka, examining their experiences and challenges of the use of CS during their academic journey. This could then be expanded to include the integration of CS strategies into the English curriculum of secondary government schools in Sri Lanka. In conclusion, investigating the different types of CS in both secondary and tertiary-level ESL classrooms could shed light on its pedagogical implications that can guide educators in optimizing language instruction, ultimately enhancing students' proficiency and fostering more effective language acquisition.

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ABBREVIATIONS

CS- Code Switching
 DELT- Department of English Language Teaching
 L2 – Second Language
 ESL– English as a Second Language
 EFL- English as a Foreign Language
 General Certificate of Education (Ordinary Level)-
 (G.C.E. O/L)
 UGC- University Grants Commission
 ELTU- English Language Teaching Unit
 L1– Native Language/ First Language or Mother
 Tongue
 TL– Target Language
 SLA- Second Language Acquisition
 SVO- Subject-Verb-Object
 SOV- Subject-Object-Verb

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L2 learners' difficulties in listening comprehension; Learners' perspectives among university undergraduate students

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ABSTRACT: *Listening skill plays a crucial role in English language learning and it demands mandatory attention in language classrooms as listening comprehension plays an important role in communicating effectively in English. Learners who study English as a second language (L2 learners) in Sri Lanka always find that comprehending English by listening is difficult. Hence this study focuses on finding out the difficulties that L2 learners face in listening comprehension based on the learners' perspectives and what students suggest to overcome those difficulties. Forty-four second year undergraduate students who are reading for their BSc in Applied Data Science Communication and those who attending to lectures conducted in English medium were given a survey to discover the difficulties they face and some of them were interviewed for further clarifications. The major difficulties emphasized by learners were the speaker's accent, speaker's pace, lack of concentration, unfamiliar vocabulary, lengthy and complex input, monotonous concepts, unclear statement made by speaker, inadequacy in asking lectures to repeat in the classroom, shortage of previous knowledge on certain topics, and noisy environment in the classroom. Students suggested practicing active listening, seeking clarification when needed, and engaging with a variety of English accents through multimedia resources to overcome listening comprehension difficulties. Based on the above findings, it implies that teachers should incorporate a variety of English accents in their teaching materials, listening exercises, and explicit vocabulary instruction also should be integrated into listening exercises focusing on both familiar and challenging words.*

Key words: *Listening comprehension, difficulties, L2 learners*

I. INTRODUCTION

Reading and listening skills are the receptive skills in which learners get the exposure to the target language. According to Namaziandost et al (2019) being exposed to the language through reading and listening assists to acquire the language. According to Chao (2013) improving listening skill has a positive impact on the development of the other skills- reading, writing and speaking. As Chao (2013) mentioned, learners should spend over 50% of the time on listening while performing in a foreign language. Seemingly, listening is one of the prominent aspects in second language learning.

Hence, vital time should be reserved for teaching listening. As Yildirim, S, Yilidirim, O (2016) providing proper instructions related to listening comprehension is necessary in English language teaching and learning process. According to Yildirim, S, Yilidirim, O (2016) in early ages of English language teaching, listening has been considered as an input that is applied only to introduce new grammar via conversations. According to Yildirim, S, Yilidirim, O (2016) in the second language classrooms, listening has been defined as the most abandoned skill and teachers have been focusing only on teaching grammar, reading and writing.

As Herath (2011/2012) emphasized, in Sri Lankan ESL (English as a Second Language) classrooms, only reading and writing skills have been taken part in the lessons and have been tested while listening and speaking skills have been neglected for years. She highlighted that listening skill has not been taught in the classrooms because it has been considered as a time-consuming skill. Therefore, many L2 learners in Sri Lanka face obstacles in learning English language due to listening comprehension problems. Generally, many degrees are conducted in English medium. As Navaz, (2018) highlighted, due to the listening comprehension problems, understanding the lectures has become a major issue for the undergraduate students in Sri Lanka. Hence, students have to apply their own strategies to overcome listening comprehension

difficulties. Based on this purpose, two research questions were developed as follows.

1. What are the listening comprehension difficulties that KDU undergraduate students face?
2. What suggestions do they make to overcome this problem?

II. LITERATURE REVIEW

This section provides a literature review on A. listening and the neglect of listening skill and B. difficulties in listening comprehension.

A. *Listening and the neglect of listening skill*

According to Walker (2014, p22-23) approximately, forty percent of our day-to-day communication is dedicated to listening. Listening is one of the most prominent skills that should be considered when it comes to English teaching – learning process. As Walker (2014) mentioned, since 1970s, listening comprehension has been questioned and estimated as a passive skill in which learners acquire a language effectively. According to Walker (2014), among all the four language skills, listening has barely undergone in research studies. Therefore, the process of how listening influences in acquiring a language and the procedure of teaching listening has somewhat been least understood (Osada, 2004). For a long time of period, listening has not been received the sufficient recognition in ESL classroom. (Walker, 2014). Over the decades, only the reading and writing skills have been tested in ESL classrooms while speaking skills have been ignored (Herath, 2011/2012). According to Herath, (2011/2012) the adequate acknowledgment for the listening is hidden behind due to writing and reading skills being over emphasized and listening being considered as the time-consuming skill to teach. Therefore, it is one of the reasons why Sri Lankan students find listening and speaking is difficult compared to the other language skills in English. Even though they have been learning English language for more than thirteen years in the school, L2 learners in Sri Lanka show lack of success in understanding listening.

B. *Difficulties in listening comprehension*

When it comes to listening comprehension, ESL students face many obstacles. According to Purwanto, Fadhly and Rahmatunisa (2021) who have conducted a study on difficulties and strategies used by college students in listening comprehension, found out that intermediate and upper-intermediate level students face listening barriers such as accents, lack of concentration, speed, lack of vocabularies and unclear statement said by speakers. Moreover, they mentioned that intermediate and upper-intermediate college students use some strategies, to conquer these

obstacles such as looking for keywords, predicting and extensive reading. According to Gilakjani, Ahmadi (2011) who have conducted a study about the facts that can be affected to EFL (Learning English as a Foreign Language) learners' English listening comprehension and the strategies for improve listening, highlighted seven issues that linked with listening comprehension. Speed of the delivery; students not being able to control the speed of the teacher's talking, not having the authority to decide listening to the certain words repeatedly, encountering unfamiliar words, failing to recognize signals such as pauses, intonation patterns, gestures, changes in the pitch and pace, lacking of contextual knowledge; context being foreign to the learners are the problems that English language learners ought to face in listening. Moreover, they figured out that if the content is not interesting enough, the learners find it hard to concentrate to the listening and even it is related to their preferences listening is difficult for learners as it demands tremendous effort to grasp the meaning. According to Bloomfield et al (2010) learners' characteristics such as working memory capacity, usage of metacognitive strategies in listening comprehension, their experience in listening to target language, anxiety level and characteristics of the content such as the length, complexity, usage of pragmatics, usage of cohesive devices and characteristics of the speaker such as accent, pauses, distortion, articulation rate are interpreted as obstacles for learners in listening comprehension. Chao (2013) pointed out, after conducting a study on factors affecting to listening problems, that listening issues can be categorized into major four components; speaker factor, listener factor, context factor, stimulus factor. Each factor indicates the listening comprehension issues including number of words learners are exposed to, vocabulary expression, quality of the speakers' utterance and the proficiency level of the learner. Gilakjani, Sabouri (2016) have found out that the standard of the listening materials that are used by the teacher, speaker's accent, cultural differences, unknown vocabulary, time duration of tasks that learners are assigned to accomplish and speed of the teacher's talking are occurred as difficulties for the learners. As Kurita (2012) highlighted the main hindrance for the learners in listening comprehension is listening skill being neglected in the language classroom. Moreover, as Stahr (2009) declared that improper pronunciation and lexical units make comprehending listening exceptionally difficult to learners. As Kurita (2012) emphasized that, learners' anxiety and stress level make comprehending listening hard for the learners. As Namaziandost et al (2019) declared that listening issues faced by learners encompass with the input that are given to the students, context, listener, process of listening, affect and types of listening task. As Namaziandost et al (2019) highlighted that, the pace

of the speech, unknown terms and concepts, lack of concentration abilities and the atmosphere where learners study influence in listening comprehension for EFL (Learning English as a foreign language) learners. According to Yildirim, S and Yildirim, O (2016) recognizing intonation, stress of the words, sentences are also defined as obstacles for L2 learners in listening.

All those studies highlighted many difficulties in listening comprehension faced by L2 learners. They declared that effective strategies, principles and approaches for teaching listening should be applied in the language classroom in order to improve the listening skills and strategies of listening comprehension should be taught to learners simultaneously to overcome the listening barriers that learners face. As an example, Gilakjani, Ahmadi (2011) claimed that three main strategies; pre-listening planning strategies, while-listening monitoring strategies, and post-listening evaluation strategies to be applied when attending listening tasks that would assist learners to clarify the objectives of the certain task and understand the language input and necessary details. If the teacher makes aware learners on the facts that influence listening such as level and parts of listening process, it ensures that learners will recognize their own abilities in listening and will engage in activities Gilakjani, Ahmadi (2011). Therefore, it is proved that teacher's role in the language classroom plays a significant role ensuring the environment is suitable enough for listening, providing authentic materials, encouraging learners to listen, modeling and training them to listen properly. As Herath (2011/2012) highlighted teaching listening being neglected in the Sri Lankan ESL classrooms as well as school students, undergraduate students who conduct their degrees in English medium face many difficulties in listening comprehension. Therefore, this study focuses on establishing the listening comprehension difficulties that faced by undergraduate students in Sri Lanka and learners' suggestions that can be applied in the ESL classroom to overcome these obstacles.

III. METHODOLOGY

C. Participants

As regards to this study, sample was selected considering all the required characteristics including participants' age, first language, the language medium they were taught in the schools and the period of time they have learnt English. Second-year undergraduate students who are reading for their BSc in Applied Data Science Communication in General Sir John Kotelawala Defence University were selected as the sample for this study as all their lectures are conducted in English medium. Most of the participants were aged 21-23 years whose first

language is either Sinhala or Tamil and they have learnt English for more than 10 years.

D. Instruments

The instrument employed in this study included a survey and semi-structured interview sessions.

1) Questionnaire

A survey (google form) which is included ten statements created using interval scale was given to the sample and forty-four responses were received. Student answered the survey in the classroom. The survey was a checklist to find out the difficulties that learners face in listening comprehension. The survey is included with statements; it is difficult to understand the lectures when lecturer has a different accent, it is difficult to understand what the lecturer says when there are many unfamiliar words in the context, it is difficult to understand what lecturer says when he/she speaks fast etc. All the participants were ensured that data would be kept securely and used for this study only.

2) Interview

After checking the responses to the survey given by participants, it is clearly proved that most of the participants are having difficulties in listening comprehension. Therefore, five students out of forty-four were selected randomly and were interviewed. Semi-structured interviews were conducted and further questions regarding to the difficulties they have been facing in listening comprehension were asked and learners presented some strategies they have applied and the suggestions that should be applied in the ESL classrooms to overcome this matter during the interview sessions.

The data collected from the survey was collated into an Excel sheet and analyzed using Excel, while the data from the interview sessions were transcribed and analyzed thematically.

IV. FINDING AND DISCUSSION

After analyzing the responses of the participants most of the participants mention that when speaker uses different accents, it gets difficult for them to understand ($SD= 0.57$, $M= 2.44$). They agree when there are many unfamiliar words used by the speaker, it is difficult for them to understand what he/she says ($SD=0.66$, $M=2.41$). Most of the participants agree that it is difficult for them to comprehend when speaker talks fast ($SD=0.82$, $M= 2.44$). One of the difficulties students agree that they face in listening comprehension is unclear statements made by speaker ($SD=0.66$, $M= 2.27$). Students agree that when they do not have any previous knowledge on the concept they listen, it is difficult for them to grasp the meaning ($SD= 0.85$, $M=2.43$). They mention that if

the topic is not interested enough which has been taught, they find difficulties in comprehending listening (SD= 0.92, M= 2.39). They highlight that when the classroom environment is too loud, they have problems in listening comprehension (SD=0.87, M=2.07). Students mention that lack of concentration is one of the reasons why they cannot comprehend what other says (SD= 0.68, M= 2.63).

Figure 1. Data collected from the questionnaire

Statement	Mean(M)	Standard deviation (SD)
1) It is difficult to understand the lectures when lecturer has a different accent.	2.44	0.57
2) It is difficult to understand what the lecturer says when there are many unfamiliar words in the context.	2.41	0.66
3) It is difficult to understand what lecturer says when he/she speaks fast.	2.44	0.82
4) It is hard to understand what lecturer says when he/she makes unclear statements.	2.27	0.66
5) It is difficult to understand what you listen when you do not have any knowledge about the topic.	2.43	0.85
6) It is difficult to understand what we listen, if the topic is not interested.	2.39	0.92
7) It is difficult to listen and understand it when the classroom is too noisy.	2.07	0.87
8) It is difficult to comprehend listening when you lose the concentration.	2.63	0.68

After transcribing and analyzing the data from the interviews thematically, two participants out of the five highlighted that when speaker uses different accents, it is difficult for them to grasp the meaning of what he/she says.

“So, do you have any difficulties understanding when someone is speaking in English? Sometimes when like they have different accents, it is hard to understand.”

“So, do you have any difficulties in understanding when you're listening to someone speaking in English? you know, like. the accent”

Two participants mentioned that depending on the speaker's pace, they find listening is difficult to comprehend.

“So, are there any difficulties you face when listening in English, other than the accent. When someone's speaking really fast.”

“do you have any difficulties in understanding when you're listening to someone speaking in English, if someone speaks really fast, like, you know”

Two students out of five mentioned that when speaker uses unfamiliar words, it gets difficult them to understand what they say.

“so, why do you think that you face difficulties in listening? Yeah, because that person uses some difficult words”

“So, do you have any difficulties when have to understand English, like when someone speaking in English? Yeah umm when words are different you know, Yeah, it means that if the speaker used some difficult vocabulary, then you have problems, right. yeah correct”


Seemingly, participants' responses imply that they find difficulties in listening comprehension when speaker uses different accents, unfamiliar vocabularies, when speaker makes some uncertain statements, the pace of speaking, lack of concentration, lack of interest on certain topics and not having previous knowledge on what they hear make listening difficult for the undergraduate students. According to the suggestions participants made, they implied that more exposure to the English language and the different English accents would make listening comprehension less difficult. They emphasized that they should use YouTube and other social media platforms to develop their listening skills.

V. CONCLUSION

As listening is one of the prominent aspects of English learning process, if learners find listening as a difficult skill to acquire, more time should be spent on improving learners' listening skills in the language classrooms. As mentioned above, undergraduate students face listening comprehension difficulties when attending lectures in English medium such as accents, unfamiliar words, uncertain statements and speaker's pace as teaching listening has been neglected in the ESL classrooms. Hence, English language teachers should give attention to teach listening applying the effective methods and approaches that are suitable for the Sri Lankan ESL classrooms incorporating different English accents to their teaching materials, assigning learners diverse listening activities as well as explicit vocabulary teaching. Researchers can investigate whether these

strategies are effective for teaching listening and introduce constructive teaching listening methods and approaches. This would assist undergraduate students to succeed in their academics as well as L2 learners to be competent in listening and effective communication as the outcome.

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VIII. AUTHOR BIOGRAPHY

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The Impact of ChatGPT on Vocabulary Development in Written Proficiency Among Sri Lankan Tertiary-Level ESL Learners

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Abstract— In an era where technology is rapidly transforming education, the potential of Artificial Intelligence (AI) to revolutionize English language learning is becoming increasingly evident. Thus, the primary aim of this study is to explore the impact of ChatGPT, a machine-learning system, on vocabulary development in written proficiency among Sri Lankan tertiary-level ESL learners. Conducted with 50 first-year undergraduates pursuing degrees in Commerce and Management Studies from the University of Kelaniya and the Australian College of Business and Technology, the research employed pre-test and post-test assessments to evaluate students' progress. Participants underwent a 20-hour intervention using ChatGPT during their English Language lectures, with significant findings highlighting enhanced vocabulary development and improved written proficiency. The research employed a mixed-method approach, utilizing pre-test and post-test assessments analyzed with the CEFR marking rubric and content analysis to explore themes and understand changes in vocabulary. Moreover, descriptive statistics was used to explore the changes in the pre-test and post-test scores. The study also emphasized a balanced approach, combining AI assistance with traditional teaching methods to ensure independent skill development. Ethical considerations and academic integrity were addressed, educating students about responsible AI use to mitigate potential issues of plagiarism. The results underscore the potential of integrating AI tools like ChatGPT into ESL curricula, offering valuable insights for educators and policymakers aiming to optimize language education. Henceforth, this research contributes to the growing body of knowledge on AI's role in language learning, particularly in contexts where English is learned as a second language, such as Sri Lanka.

Keywords: ChatGPT, English as a Second Language, Vocabulary development

I. INTRODUCTION

The rise of Artificial Intelligence (AI) in education, particularly within the realm of English language learning, has garnered significant scholarly attention (An et al., 2023; Hwang et al., 2020; Ji et al., 2023). Henceforth, McCarthy (1955) emphasizes AI as the science and engineering focused on creating intelligent machines. In the field of education and language pedagogy, AI holds promise to revolutionize learning and instructional methodologies (An et al., 2022). Accordingly, the advent of Chat Generative Pre-Trained Transformer (ChatGPT); “a machine-learning system that autonomously learns from data and can produce sophisticated and seemingly intelligent writing after training on a massive data set of text” (van Dis et al., 2023 p. 224), marked a pivotal moment in English language learning and teaching process. Thus, according to Huang et al. (2022), ChatGPT serves as an invaluable resource for language learning, offering learners opportunities to enhance reading, writing, grammar, and vocabulary skills. Scholars have extensively examined AI's role in education, exploring various applications such as chatbots for English language learning (Annamalai et al., 2023), AI-based writing assistants for EFL students (Gayed et al., 2022), and comparisons of AI-powered tools in improving English grammar (Schmidt-Fajlik, 2023).

In Sri Lanka, where English functions as a second language, learners often encounter challenges, particularly with reference to writing tasks. Crucially, Abu (2001) accentuates that writing poses challenges for both native and non-native speakers, as it requires managing multiple aspects such as content, structure, intended audience, vocabulary, grammar, spelling, and technical details. Hence, it is a discernible truth that English as a Second Language (ESL) learners struggle with sourcing content and appropriate vocabulary in their writing process. As a consequence of this, in the contemporary educational realm, ESL

learners tend to use ChatGPT as it has significant implications on the writing process (Alkaissi & McFarlane, 2023) predominantly with reference to the issue of “plagiarism and academic honesty” (Halaweh, 2023 p. 3). Yet, due to the novelty of AI technology, there has been limited research conducted on its implementation in education, particularly in enhancing vocabulary development in written proficiency among tertiary-level ESL learners. Therefore, this study aims to explore how ChatGPT influences vocabulary development in written proficiency among tertiary-level ESL learners in Sri Lanka. Additionally, it seeks to assess how this AI tool can facilitate students in enhancing both their vocabulary skills and overall writing proficiency. By exploring these dimensions, the research aims to contribute to the growing body of knowledge on AI’s role in language education, particularly in contexts where English is learned as a second language, such as Sri Lanka.

The study employed a qualitative approach, employing a formal, objective, and systematic process to analyze gathered data in order to investigate the research question.

- How does ChatGPT influence vocabulary development in written proficiency among Sri Lankan tertiary-level ESL learners?

II. LITERATURE REVIEW

Vocabulary development is a critical component of language acquisition, particularly in ESL contexts. Extensive research has highlighted the importance of vocabulary in enhancing written proficiency among learners (Nation, 2001; Schmitt, 2008). According to Laufer and Nation (1995), learners require a threshold of lexical knowledge to produce meaningful written texts, and limited vocabulary often results in less sophisticated writing. Digital tools, such as online dictionaries and language learning apps, have been shown to positively influence vocabulary acquisition (Godwin-Jones, 2011). Recent studies have also examined the role of AI-based tools like ChatGPT, which incorporate natural language processing (NLP) to provide immediate feedback and suggestions during writing (Ziegler et al., 2020). Crucially, these tools are believed to scaffold language learning by offering lexical choices, synonyms, and contextualized usage, allowing learners to expand their vocabulary and refine their writing skills. However, there is still limited empirical evidence on the extent to which AI tools specifically impact ESL learners’ vocabulary development, particularly in non-native English contexts like Sri Lanka. Despite the growing body of research on AI-based language learning, few studies have explored the

effects of ChatGPT on the written proficiency of tertiary-level ESL learners in Sri Lanka. While some global research has investigated the potential of AI to enhance language skills, there remains a gap in understanding how these technologies are adapted to local educational settings where learners face distinct challenges, such as limited access to resources and variations in English proficiency. Additionally, studies focusing on tertiary-level learners often emphasize the improvement of general writing skills (e.g., grammar and coherence) but rarely isolate vocabulary development as a primary outcome. Thus, the present study aims to bridge the gap by specifically examining how ChatGPT affects vocabulary development among Sri Lankan ESL learners, contributing to the understanding of AI’s role in supporting language acquisition in under-researched contexts

III. METHODOLOGY

9) Participants

A total of 50 first year undergraduates (25 each) of the University of Kelaniya and Australian College of Business and Technology were selected as samples for this study. The age of the students ranged between 17 – 21 years. The selected sample corresponded to the CEFR-B1 level. Students from both universities were studying English Language as a compulsory subject during their first semester.

10) Procedure

The participants undertook a 20 minute pretest consisting of a 100-150 word paragraph writing question, under the topic ‘The Impact of ChatGPT on Vocabulary Development in Written Proficiency Among Sri Lankan Tertiary-Level ESL Learners’ The pretest was assessed based on the CEFR vocabulary component. Subsequently, 2-hour sessions were conducted over 10 days, during which the students were taught using ChatGPT as a language learning tool during their English Language lectures. A total of 20 hours (10 hours of demonstration and 10 hours of practice) were completed prior to the post-test.

The post-test was held on the 11th day, involving the same paragraph writing task as the pretest, with an equal time duration and the word limit. The students were tested on their development of vocabulary and the post-test was evaluated based on the CEFR vocabulary component.

The data collected from the marks obtained from the pretest and post-test were analyzed and interpreted using a mixed approach. Content analysis method allowed a detailed exploration of

themes identified within the vocabulary development in the writing skills of Sri Lankan ESL tertiary-level learners.

IV. FINDINGS AND DISCUSSION

After conducting the pre-test and post-test assessments, the researchers identified several key findings that shed light on the impact of ChatGPT as a language learning tool on the vocabulary development in the writing skills of Sri Lankan ESL tertiary-level learners.

4.1 Enhanced Vocabulary Development

Lexical analysis of learners' performance indicated that those who used ChatGPT had higher lexical complexity thus, supporting the recent research about AI in language acquisition (Godwin-Jones, 2022; Fitria, 2022; Lu, 2021). The real-time feedback provided by ChatGPT not only introduced students to new vocabulary but also helped them understand its contextual usage, leading to a more accurate and nuanced understanding of word meanings. According to Lu (2021), AI-assisted language platforms can promote a deeper comprehension of vocabulary through immediate, contextual feedback, which is critical for second language learners who often struggle with intricacies in word usage. Furthermore, the increased exposure to varied vocabulary aligns with the work of Alharthi (2020), who noted that digital tools enhance lexical acquisition as it provides learners with rich linguistic input in an interactive setting. This is reflected in the findings of the present study, where participants actively engaged with the tool to expand their lexical range.

4.2 Improved Written Proficiency

A significant improvement in students' written proficiency was observed, particularly in sentence structure, coherence, and grammatical accuracy. This is consistent with existing literature which emphasises the role of AI in facilitating development in writing through continuous, cyclical process of feedback (Hao & Lei, 2021; Godwin-Jones, 2022). Lin (2020) elaborates that the interactive nature of AI feedback fosters a more engaged learning experience, where students are motivated to refine their work continually. The present study revealed that students benefitted not only from grammar corrections but also from more complex feedback on coherence and style, leading to a more refined writing output. These findings reinforce the argument by Zheng and Yu (2019) that AI-assisted writing tools offer learners the opportunity to engage in meaningful revisions, which improves writing quality over time. Furthermore, AI's role in increasing student motivation, as

identified by Henrickson (2022), was confirmed in this study where the learners demonstrated enthusiasm and determination in improving their written work.

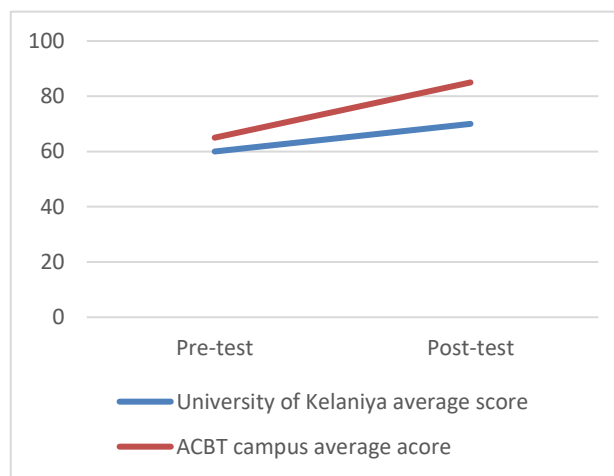


Figure 01

4.3 Practical Application and Engagement

The study revealed that practical demonstration sessions combined with practice opportunities significantly enhanced student engagement. As demonstrated by previous studies (Fitria, 2022; Lin, 2020), learners were more motivated to use AI tools as they were able to directly see the practical benefits of enhanced writing skills. ChatGPT's immediate feedback fostered a wide variety of experimentation with complex sentence structures and advanced vocabulary within the language learning classrooms, a finding that resonates with Dizon and Tang (2021), who showed that AI tools encourage learners to venture beyond basic language structures. Additionally, these findings also align with Vygotsky's Zone of Proximal Development (Vygotsky, 1978), suggesting that AI serves as an effective scaffold, guiding learners to confidently execute and achieve tasks slightly beyond their current ability. This was further supported by the work of Goh and Burns (2012), who argued that confidence-building through guided practice is essential for fostering language learning.

4.4 Balanced Approach to Learning

The research emphasized a balanced approach, combining AI assistance with traditional teaching methods. This approach ensured that students did not become overly reliant on AI tools and continued to develop independent writing skills. A balanced approach, combining AI assistance with traditional instruction, proved to be the most effective in the long-term development of students' writing skills.

This finding is in line with research by Li (2021) and Zheng and Yu (2019), which suggests that an overdependence on AI tools, without the involvement of teachers, can hinder the development of independent writing skills. The present study found that students who balanced AI usage with traditional learning methods, such as classroom instruction and discussions, retained vocabulary and grammatical structures more effectively than those who depended solely on AI tools. This reflects the observations of Liu et al. (2020), who suggested that the integration of technology with face-to-face instruction results in more holistic language learning outcomes. Additionally, the study supports previous research by Warschauer (2015), who emphasized that while AI can enhance language learning, it should not replace human interaction and traditional pedagogical techniques, which are essential for fostering critical thinking and autonomous learning.

4.5 Differences Between University Types

The study identified differences between private university students (ACBT campus) and state university students (University of Kelaniya) in terms of vocabulary and writing proficiency improvement. Private university students showed more significant gains, a result that could be attributed to better access to technological resources and more frequent exposure to English in their academic settings. This finding is consistent with the work of Dziuban et al. (2018), who found that learners in institutions with more advanced technological infrastructure tend to achieve higher language proficiency. Similarly, the role of socio-economic factors in determining students' access to educational technology, as discussed by Warschauer and Matuchniak (2010), may explain the disparities observed in this study. The unequal access to resources among different educational institutions mirrors the "digital divide" discussed by Selwyn (2013), which remains a significant factor in the unequal distribution of educational outcomes in improving language proficiency among tertiary level learners in Sri Lanka.

4.6 Ethical Considerations and Academic Integrity

The study highlighted the importance of clear guidelines and educational policies to prevent the misuse of AI tools. Students were educated about academic integrity and the ethical use of AI, which mitigated potential issues of plagiarism and academic dishonesty. Students were made aware of the responsible use of AI as educating students on the ethical use of technology is essential to prevent misuse of such tools. The implementation of clear guidelines, as advocated by Magnus et al. (2021),

ensured that students viewed AI tools as supportive learning aids rather than shortcuts. This study highlights the importance of integrating ethics into AI-assisted learning environments.

CONCLUSION

In conclusion, this study elucidates the significant impact of ChatGPT as a language learning tool on the vocabulary development and written proficiency of Sri Lankan tertiary-level ESL learners. Through a robust methodological framework, including pretests and post-tests, the findings reveal that engagement with AI technology not only enhances lexical complexity and overall writing quality but also fosters greater student motivation and engagement. The data corroborate existing literature on the efficacy of AI-assisted language learning, particularly in providing real-time feedback that facilitates nuanced understanding of vocabulary and improved writing coherence.

Moreover, the study emphasizes the necessity of a balanced pedagogical approach that integrates AI tools with traditional teaching methods, thereby preventing overreliance on technology while promoting independent learning skills. Notably, the observed differences in proficiency advances between students from different types of institutions highlight the role of access to resources and educational equity, emphasizing the need to address the digital divide in Sri Lanka's educational landscape.

Ethical considerations surrounding the use of AI in education are also paramount. The incorporation of guidelines on academic integrity is crucial to fostering a responsible use of technology among students. This study not only contributes to the growing body of research on AI in language acquisition but also provides practical implications for educators seeking to leverage technology effectively within diverse learning environments. Future research could expand on these findings by exploring long-term impacts of AI-assisted learning on language proficiency across various educational contexts.

LIMITATIONS AND RECOMMENDATIONS

Future researchers investigating ChatGPT's impact on vocabulary development in written proficiency among Sri Lankan tertiary-level ESL learners should focus on several areas, including the long-term effects on vocabulary retention, a comparison with traditional teaching methods, and the tool's adaptation to the cultural and linguistic nuances of the learners. Additionally, understanding how ChatGPT affects learner autonomy, motivation, and perceptions could

offer valuable insights, particularly in resource-limited contexts. It will also be important to explore its effects across various proficiency levels and address ethical concerns regarding AI integration in education to inform future pedagogical practices.

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Distribution Patterns and Challenges of Multi Country Consolidation in the Port Authority of Sri Lanka

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Abstract— Sri Lanka has managed transshipment and Multi-Country Consolidation (MCC) operations at the Port of Colombo for the past 20 years by utilizing its strategic advantages. MCC is a crucial procedure in international logistics since it entails the consolidation of Less than Container Load (LCL) shipments from numerous origins to diverse destinations, or vice versa. In comparison to more established ports such as Singapore, Dubai, and Salalah, Colombo Port is still in its early stages of MCC development, despite its potential. Nonetheless, by implementing best practices and fully utilizing its competitive advantages, there is a great deal of space for improvement. At the moment, these MCC operations are solely managed by the Sri Lanka Ports Authority (SLPA). The challenges the SLPA facing are to track the origins and destinations of cargo and the storage period in warehouses. Real-world data, for three months, was used in this study to create predictive models and analyse the distribution patterns. Important factors like cargo origin and destination, cargo types and classifications, and the time periods covered by MCC operations are the main subjects of the study. To analyse cargo routes, find operational inefficiencies, and improve port logistics. The usefulness of each model in accomplishing the study goals is carefully considered, offering insightful information on how to improve MCC operations at Colombo Port.

Keywords— Data visualization, multi-country consolidation, origin, destination

I. INTRODUCTION

Around 7 to 8 years ago, the maritime industry predominantly operated small ships with drafts of approximately 8m, 10m, and 12m, resulting in limited capacities ranging from 800 to 2500 TEU. Shipping companies sought to counteract this trend due to increased operational costs associated with smaller

vessels. Consider a hypothetical scenario with a shipping line like "MAERSK Lanka," exclusively employing small ships. Despite their size, these vessels incurred higher costs due to maintaining a crew comparable to that of larger ships. This led to increased expenditure on accommodation and food, raising overall operational costs.

To address this issue, the industry transitioned to larger ships with drafts of 18m or 20m, accompanied by service improvements. Ports adapted by enhancing services, allowing companies to reduce costs. Larger ships required fewer crew members than the cumulative crew needed for numerous smaller vessels, leading to increased capacity and cost savings. Customers benefited from these efficiencies, experiencing lower charges, particularly in comparison to TS cargo.

Consider a container arriving from China with a 40" TEU containing only TS. Containers may carry a variety of cargo types, including General Cargo, DC, TS, Multi-Purpose MCC, Ship Spares, Liquor, Port Authority Cargo, and Forces Cargo. Upon arrival, containers are directed to warehouses.

In Sri Lanka, the port authority oversees the warehouse complex, consisting of BQ Complex, CFS-1, Peta, and Paliyagoda. Manifest submissions are done physically and online at the Canal Yard. After a thorough check, containers are assigned to specific warehouses for destuffing. The port authority allocates space from these four areas and directs TS tanks to CFS-1, which, when programmed, transfers DC and General cargo to BQ. The destuffing process is recorded in a tally within BQ, comprising BQ-1, BQ-2, BQ-3, and BQ-4.

Each BQ warehouse has a designated purpose:

- BQ-1 and BQ-4 destuff General Cargo
- BQ-2 destuffs DC

-BQ-3 destuffs TS/MCC

Agents check the destuffing of General Cargo in BQ-1 and BQ-4. After manifest verification, LDC begin unloading containers, physically checking details and deciding the warehouse placement, all documented in the tally.

Consider the example of a private forwarder, CWD, handling an MCC container. CWD allocates this container to BQ-1 for General Cargo and BQ-3 for TS, contrary to a port-wise allocation. The port authority assigns space based on agents rather than port locations. CWD, within a 21-day grace period, plans container filling. If unable to complete within the timeframe, the agent may transfer the container to another shipping line. This encapsulates the detailed process of MCC handling within the maritime industry.

II. METHODOLOGY

The research aims to enhance the efficiency and competitiveness of MCC operations at the Port of Colombo by conducting a comprehensive study on the origin and destination of MCC cargo, identifying areas for improvement, and implementing strategies to increase volume and revenue. This study addresses a critical gap in understanding MCC operations at the port, focusing on optimizing processes and maximizing operational efficiency.

A. Conceptualization of Variables

Understanding and maximizing the effectiveness of maritime logistics is dependent on several critical factors in the context of MCC operations at the Port of Colombo. These variables cover a wide range of MCC operations and play a major role in accomplishing the goals of the research, which include improving operational efficiency, cutting costs, and raising volume and revenue.

The origin and destination of MCC cargo is one important variable. The geographic places where MCC cargo originates and is finally delivered are indicated by this variable. To recognize patterns, trends, and demand dynamics in international trade routes, it is imperative to comprehend the origins and destinations of MCC cargo. The objective of the research is to enhance operational efficiency and revenue generation at the Port of Colombo by identifying potential areas for route optimization, capacity planning, and service improvement through the analysis of this variable.

Another important variable is the type and classification of MCC cargo. Including general,

perishable, hazardous, and specialized items, is crucial for identifying demand variations, handling requirements, and value-added services, thereby aiding in the development of tailored strategies for port management and handling.

Additionally, the time periods managed by MCC operations are crucial for optimizing port operations and resource allocation. These include peak seasons, transit times, and delivery schedules. Analysing these periods helps identify capacity constraints, resource bottlenecks, and operational inefficiencies that may affect service quality and customer satisfaction. The research aims to develop scheduling and resource allocation strategies to improve operational flexibility, reduce congestion, and enhance service reliability at the Port of Colombo. This comprehensive framework helps understand maritime logistics complexities and drives sustainable growth in international trade.

B. Output & Operationalization

The research on MCC operations at the Port of Colombo aims to enhance operational efficiency, increase volume, and reduce costs. This is crucial for sustainable growth and competitiveness in maritime logistics. The expected outputs include strategies for increasing volume, such as identifying emerging trade routes, untapped markets, and strategic partnerships. Analysing the origin and destination of MCC cargo, as well as the types and classifications of cargo, can help expand service offerings, attract new customers, and increase throughput.

To operationalize these outputs, the research employs a systematic approach to data collection, measurement, and analysis. Quantitative data is collected from port records, customs databases, and other relevant sources, while qualitative data is collected through stakeholder interviews.

The operationalization of variables in the research provides a comprehensive and data-driven approach to understanding and optimizing MCC operations at the Port of Colombo. By generating actionable insights and strategies, the research aims to contribute to the sustainable growth and competitiveness of maritime logistics in the region.

C. Data Collection

The research on MCC operations at the Port of Colombo involves identifying key variables, selecting appropriate sources of data, and implementing methods for collecting and measuring these variables. The variables include cargo origin and destination, types and classifications of cargo, and time periods managed by MCC operations.

The data collection process involves gathering quantitative and qualitative data from various sources,

including port records, stakeholder interviews, and industry reports. Quantitative data, such as cargo manifest data and operational metrics, will be collected from port records and customs databases, while qualitative data, such as stakeholder interviews and expert opinions, will be gathered through semi-structured interviews and focus group discussions.

The data collection process aims to generate insights and recommendations for optimizing MCC operations and enhancing the port's competitiveness in maritime logistics. By collecting and measuring key variables, the research aims to provide valuable insights for optimizing MCC operations and enhancing the port's competitiveness in maritime logistics.

D. Model Building

The research on MCC operations at the Port of Colombo uses three key models: DB Scan, Computational Process Engineering, and Origin-Destination Matrix, to analyse cargo routes, identify operational inefficiencies, and optimize port logistics. Each model's application and relevance to the research objectives are explained.

1. Explanation of Models:

DB Scan: DB Scan is a clustering algorithm used to identify clusters of data points in a spatial dataset based on density. It groups together data points that are closely packed, forming clusters while also identifying outliers or noise points. DB Scan is particularly useful for analysing MCC cargo routes by identifying clusters of origin-destination pairs and determining the density of cargo flow between different locations.

Computational Process Engineering: Computational Process Engineering involves the use of mathematical modelling and simulation techniques to optimize industrial processes. In the context of MCC operations at the Port of Colombo, Computational Process Engineering can be used to model and simulate various port operations, such as cargo handling, vessel scheduling, and terminal management. This model enables the analysis of different scenarios and the evaluation of strategies for improving operational efficiency and reducing costs.

E. Data Analysis Tools

Power BI is a Microsoft business analytics tool that enables real-time data visualization, analysis, and interpretation. It connects users to multiple data sources, including databases, spreadsheets, and cloud services, and allows for interactive visualizations and

reports. Power BI will be used for data visualization, analysis, and interpretation in research on MCC operations at the Port of Colombo. Researchers will use it to create interactive visualizations, analyse data, and interpret findings.

Figure 2. Dashboard created by using Power BI

III. Results

The first research, conducted by HR Gajanayaka and MRS Mudunkotuwa in 2015, examines the potential of expanding Colombo Port as a key Multi-Country Consolidation (MCC) center in Southeast Asia. The study identifies six critical factors influencing the success of MCC activities at the port: consolidation costs, ship operations, value-added services, freight costs, customs operations, and indirect operations. The authors argue that expanding Colombo Port as an MCC center is both cost-effective and competitive, highlighting its significance in facilitating efficient regional trade.

In their 2018 study, "Resource-Aware Container Consolidation Using a Deep Learning Approach," Saurav Nanda and Thomas J. Hacker introduce the Resource-Aware Container Consolidation (RACC) algorithm, a deep reinforcement learning method for optimizing container consolidation with varying resource needs. Their system outperforms baseline alternatives in terms of efficiency, achieving a training accuracy of 82.01% and an average testing accuracy of 82.93%. This research advances container consolidation processes by applying deep learning techniques, showcasing their potential to enhance resource efficiency and operational effectiveness.

IV. Conclusion

The main purpose of this study was to evaluate the factors that impact the development of Colombo port as a major MCC hub in the South Asia region. However, when focusing on the existing information or the secondary data, there are not many primary studies that have been conducted in the past about the same topic of this research study. Hence, initially, the study has identified there is a considerable gap between the primary data and secondary data that are relevant to the research topic. The main objectives of this research study were to identify the factors that influence the overall MCC service level in terms of the number of FCL containers of Port of Colombo and to propose solutions to enhance the overall service level of MCC in terms of the number of FCL containers at Port of Colombo regarding identified factors. To collect primary data, the study has conducted a qualitative research study, and the sampling technique was convenience sampling. As the research tool or the instrument, a semi-structured



interview guide has been used. By conducting interviews for 5 clients, the study has collected findings to accommodate the first objectives, and to accommodate the second objective, the study has presented recommendations. The major findings of this study are that to enhance the MCC activities of the Colombo port, the port management should enhance its efficiency level and furthermore, the port should accommodate modern technological equipment within the port. Moreover, the staff should have a proper training to provide an efficient service to port clients as it directly impacts the overall efficiency and the convenience of the port clients.

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ABBREVIATIONS AND SPECIFIC SYMBOLS

CFS-1 – Container Freight Station
 DB Scan -Density-Based Spatial
 DC -Dry Cargo
 FCL- Full Container Load
 LDC -Landing Delivering Clerks

MCC- Multi Country Consolidation

SLPA – Sri Lankan Port Authority

TS-Tanker Ships

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ID 353

Predictive Modeling of Obesity Trends Using Machine Learning Techniques

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Abstract

Obesity prevalence is on the rise, presenting a host of health problems for major portions of the world; effective

predictive modeling has been brought to the fore to assist in public health intervention. This study analyzes and predicts the level of obesity on the ground based on various variables, applying a wide-ranging dataset from the UCI Machine Learning Repository. K-Nearest Neighbors, Random Forest, Decision Tree, Support Vector Machine, clustering, and regression analyses are some of the machine learning techniques applied in this research. This returned an accuracy of 94.32%, a precision of 95%, a recall of 94%, and an F1 score of 94%. The findings on the best-predicting models of obesity are of major importance in informing improved public health strategies and interventions. This research, therefore, identifies the role of machine learning in the identification of trends in obesity and calls for improved versions of these predictive models.

Keywords: Obesity, Machine Learning, K-Nearest Neighbors, Random Forest, Decision Tree, Regression

INTRODUCTION

According to the World Health Organization (WHO), obesity and overweight are conditions characterized by abnormal accumulation of body fat that may negatively affect the health of an individual (Dirik, 2023). Over the last 40 years, the rate of childhood obesity has increased tremendously around the world. A recent simulation of the growth trajectory estimated that by 2025, half of all the children worldwide would be obese (Lim et al., 2023). The prevalence has continued to be documented over recent decades and has grown to become an issue for all age groups, both genders, and all income brackets. The global rate of obesity has nearly tripled since 1975, according to the WHO. Over 1.9 billion adults fall in the overweight category, out of which more than 650 million cases are obese. The possible burden that this may put on healthcare systems and economies includes not only associated medical costs but also lost productivity.

Physiology, individual psychology, food production, food consumption, physiology, individual physical activity, genetic and cultural influences, and physical activity environment are some of the causes of obesity (Jeon et al., 2022). The complex genetic predisposition to obesity is influenced by the metagenomes of the

microbiota that live in the human body as well as the human genome. It has been discovered that some genetic variations influence the regulation of appetite and energy metabolism, leading to an imbalance between consumption and intake of energy that ultimately results in obesity (Dirik, 2023). It is now known that sleep issues increase the risk of obesity in adolescence¹⁸. Sleep plays a critical role in energy-restoring and metabolism processes. It influences glucose metabolism¹⁹, food intake^{20–21}, and appetite regulation. Crucially, adolescence brings about significant changes in sleep due to biological and environmental and social factors that result in later bedtimes but early mornings for school²². As a result, young people are more likely to experience inadequate or poor sleep, particularly those from high socioeconomic backgrounds.^{23, 24}, and so forth is becoming more common for teenagers in the US to not get enough good-quality sleep. With the increase of wearables is the added benefit of continuously identifying and monitoring quantifiable behaviors, like movement, sleep, and cardiovascular (CV) fitness metrics, which may be critical risk factors for obesity in adolescents (Kiss et al., 2024).

There is a wide range of chronic health conditions linked to obesity. Among them are: - Type 2 diabetes: Obesity increases the risk of type 2 diabetes by decreasing insulin sensitivity and increasing insulin resistance. Obesity is a major risk factor for hypertension because it puts extra strain on the heart and blood vessels, which raises blood pressure. Heart disease and stroke risk: The likelihood of developing heart disease, stroke, and other risk of cardiovascular diseases increases with obesity. Osteoarthritis: The additional stress that obesity places on joints, especially the hips and knees, frequently causes osteoarthritis. Depression: The likelihood of depression is increased when obesity is present, most likely linked to the negative effects of obesity on the body and mind. Alzheimer's disease: An elevated risk of Alzheimer's disease and related disorders. Obesity and dementia are related. Cancer: Being obese increases the chance of developing a

number of cancer types, including but not limited to cancers of the breast, prostate, kidney, ovary, liver, and colon. It is crucial to emphasize that the wellbeing of the risks listed above are only a few of the many possible issues connected to fatness. Because of this, managing and treating obesity is extremely important to reduce the likelihood of developing these and other long-term medical issues (Lawas, 2023).

Among the many technologies that have been used to identify the causes and treatments of weight problems is the application of machine learning. Machine learning has contributed to change in many different fields, including well-being. It produces a precise outcome in showcasing the capabilities of the classification challenges. This will provide a balanced dataset with actual information on how to discover the causes of weight issues, particularly obesity, using the application of machine learning (Dirik, 2023).

In this study, a summarized dataset is harnessed from the UCI Machine Learning Repository for building and testing predictive models of obesity classification. To this end, different Machine Learning techniques, viz., K-Nearest Neighbors, Random Forest, Support Vector Machine (SVM), Decision Tree and regression analyses, had been harnessed to build plausible models that forecast obesity levels at maximum accuracy. It is then that information from such models could contribute to improved public health strategies and interventions, and in the end, reduce obesity rates and hence health risks.

The paper has threefold objectives: first, the preprocessing of the dataset for analysis in identifying important features that cause obesity; second, to apply and evaluate models of machine learning in rating the levels of obesity; third, interpreting the results in order to provide actionable insights for public health policy and individual health management. It is our hope that with this approach we can demonstrate one way in which machine learning might help in enhancing our understanding and management of obesity and, in turn, pave a path for much more effective health programs.

A. Data Description

The dataset used in this study [28] contains information that allows the degree of obesity of a person to be judged based on their dietary habits and physical condition. This dataset contains 2111 instances (rows) and 17 variables (columns) of numeric, binary, and categorical input variables. There is one target or outcome variable that provides data regarding a person's level of obesity. This dataset is labeled "NObesity"; the classes are the following: Underweight, Normal Weight, Obesity Level I, Obesity Level II, Obesity Type I, Obesity Type II, and Obesity Type III. Table 2 illustrates all the data variables used. It includes variable names, data types, and exact definitions.

Table 1. Dataset description

Attributes	Values
Gender	1 = Female or 0 = Male
Age	Numeric
Height	Numeric
Weight	Numeric
Family with overweight / obesity	1 = Yes/ 0 = No
FAVC (frequent consumption of high caloric food)	0 = Yes/ 1 = No
FCVC (frequent consumption of vegetables)	1,2 or 3
NCP (number of main meals)	1, 2, 3 or 4
CAEC (consumption of food between meals)	(1 = No, 2 = Sometimes, 3 = Frequently or 4 = Always)
Smoke	0 = Yes/ 1 = No
CH20 (Consumption of water daily)	1, 2 or 3

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SCC (Calories consumption monitoring)	0 = Yes/ 1 = No
FAF (Physical activity frequency)	0, 1, 2 or 3
TUE (Time using technology devices)	0, 1 or 2
CALC (Consumption of alcohol)	1 = No, 2 = Sometimes, 3 = Frequently or 4 = Always
MTRANS (Transportation used)	Automobile, motorbike, bike, public transportation or walking
Obesity level	1 = Insufficient_Weight, 2 = Normal_Weight, 3 = Overweight_Level_I, 4 = Overweight_Level_II, 5 = Obesity_Type_I, 6 = Obesity_Type_II, 7 = Obesity_Type_III

For each of them, the Mass Body Index was obtained according to the formula Body Mass Index (BMI) = weight / height \times height. With the obtained BMI for each individual, the values were compared using the classification thresholds given by the WHO and the Mexican Normativity. As such, those people who have a BMI less than 18.5 are considered underweight, while those having a BMI from 18.5 to 24.9 are classified as normal weight. On the other hand, individuals with a BMI of 25.0-29.9 are overweight, between 30.0 and 34.9, Class I obesity, from 35.0 to 39.9, Class II obesity, and above 40, Class III obesity. These classifications were important in analyzing and making a prediction of obesity levels using different machine learning models.

B. Data Preprocessing

This included handling missing values, encoding categorical variables, and normalizing numerical features independently in the dataset. Categorical variables were handled by label

encoding; on the other hand, numerical features were standardized using the Standard Scaler in order to introduce uniformity and improve the performance of the model.

C. Models

Machine learning is one of the fastest-growing fields that has taken the forefront in recent years. It is a discipline concerned with the scientific study of algorithms and statistical models used by the computer systems in performance in the absence of explicit instructions. The ultimate objective of machine learning is enabling computers for better and efficient use of data through a process termed reinforcement learning.

In this research, different the techniques of machine learning were used: Prediction and analysis of the levels of obesity; a non-parametric approach for classification—the K-Nearest Neighbors method; another ensemble learning method suitable for classification, regression, and other tasks: Random Forest; Clustering techniques: K-Means, a method that will partition the observations into k clusters; and Hierarchical Clustering, a method that builds a hierarchy of clusters. Moreover, regression models were considered to analyze the relationship between variables in the study, when relevant, so as to provide comprehensive ways of understanding and predicting obesity trends.

RESULTS AND DISCUSSION

A. Correlation and coefficient

The **correlation coefficient** is a statistical measure that describes the strength and direction of a relationship between two variables.



Figure 1. Correlation between BMI and features

We can predict **weight** based on **height** and **age** since these variables have moderate correlations with weight. **TUE** could be predicted based on **age**, given the negative correlation. Other variables like **FCVC**, **NCP**, and **CH2O** might not be strong predictors of weight or other factors due to their low correlations.

B. Evaluation Metrics

The main evaluation measures for classification problems include accuracy, precision, recognition, and the F1 score. Accuracy reflects the ratio of correctly classified instances to the total number of instances. Precision represents the proportion of correct positive predictions to all positive predictions. Recall, also referred to as sensitivity or ‘true-positive rate,’ indicates the ratio of correct positive predictions to the total number of correct positive instances. The F1 score, a measure of a classifier’s balance between precision and recall, is calculated as the harmonic mean of precision and recall.

C. Classification

K-Nearest Neighbors (KNN): The model KNN returned an accuracy of 86.99%, precision of 87.05%, recall of 86.99%, and an F1 score of 86.27%. Classification report details how the performance of this model is related to the various levels of obesity. It has substantial precision and recall for normal weight and the category of overweight.

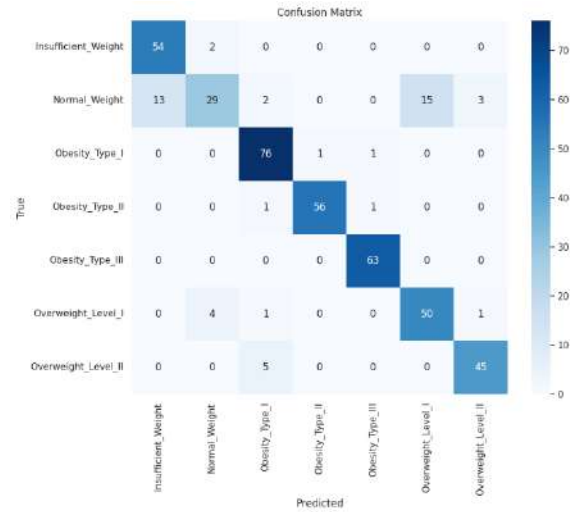


Figure 2. Precision-Recall Curve for KNN Model

The confusion matrix provides a helpful way to visualize the performance of a classification model and identify areas for improvement.

KNN Model Accuracy: 0.862776025236593

Classification Report for KNN:

	precision	recall	f1-score	support
0	0.79	0.94	0.86	86
1	0.75	0.48	0.59	93
2	0.88	0.95	0.92	102
3	0.98	0.95	0.97	88
4	0.96	1.00	0.98	98
5	0.77	0.85	0.81	88
6	0.89	0.85	0.87	79
accuracy			0.86	634
macro avg	0.86	0.86	0.85	634
weighted avg	0.86	0.86	0.86	634

Figure 3. Classification report for KNN Model

Random Forest Model Accuracy: 0.943217665615142

Classification Report for Random Forest:

	precision	recall	f1-score	support
Insufficient_Weight	0.99	0.95	0.97	86
Normal_Weight	0.83	0.91	0.87	93
Obesity_Type_I	0.98	0.96	0.97	102
Obesity_Type_II	0.97	0.99	0.98	88
Obesity_Type_III	1.00	0.99	0.99	98
Overweight_Level_I	0.89	0.85	0.87	88
Overweight_Level_II	0.96	0.94	0.95	79
accuracy			0.94	634
macro avg	0.94	0.94	0.94	634
weighted avg	0.95	0.94	0.94	634

Figure 4. Classification report for Random Forest Model

Decision Tree Model Accuracy: 0.916403785488959				
Classification Report for Decision Tree:				
	precision	recall	f1-score	support
0	0.88	0.97	0.92	86
1	0.83	0.81	0.82	93
2	0.98	0.92	0.95	102
3	0.95	0.98	0.96	88
4	1.00	0.99	0.99	98
5	0.87	0.81	0.84	88
6	0.89	0.95	0.92	79
accuracy			0.92	634
macro avg	0.91	0.92	0.91	634
weighted avg	0.92	0.92	0.92	634

Figure 5. Classification report for Decision Tree Model

SVM Model Accuracy: 0.8801261829652997				
Classification Report for SVM:				
	precision	recall	f1-score	support
0	0.84	0.98	0.90	86
1	0.89	0.67	0.76	93
2	0.93	0.94	0.94	102
3	0.94	1.00	0.97	88
4	1.00	0.99	0.99	98
5	0.76	0.81	0.78	88
6	0.78	0.76	0.77	79
accuracy			0.88	634
macro avg	0.88	0.88	0.87	634
weighted avg	0.88	0.88	0.88	634

Figure 6. Classification report for SVM Model

The results of the study show that the Random Forest (RF) classifier had the best performance in terms of accuracy, with a result of 94.32%. The Decision Tree classifier had the second-best performance with a result of 91.64 %. The Support Vector Machine (SVM) classifier achieved 88.01 %, while the KNN classifier achieved 86.27 %. Overall, the RF classifier was the most effective in accurately classifying and identifying obesity.

D. Clustering

K-Means and Hierarchical Clustering were applied for finding a pattern within this dataset. Both of these above-mentioned findings gave insight into probable grouping and relations between features, which helped in understanding obesity patterns.

In our clustering analysis, we identify three distinct clusters representing different groups based on several attributes pertaining to eating habits and physical conditions.

Cluster 0 is characterized by people who are somewhat older than average but far below average in height. These subjects also showed below-average weight, main meals, water intake,

frequency of physical activity, and use of technology, while their frequency of vegetable consumption was close to average. This may be a young group with reduced height and weight, below-average main courses, water intake, physical activity, and technology usage.

Cluster 1 consists of people who are below average in age and weight but have near average height. Such individuals have below-average FCVC and above-average NCP, FAF, and TUE, while their CH2O is near average. This cluster perhaps typifies young subjects with average height but below average weight, where main meals, physical activity, and technology use are above average.

The second cluster includes individuals slightly above the average age, more than the average height, and far above the average weight. These subjects also have above average values of FCVC, NCP, and CH2O, close to average values of FAF, and below average values of TUE. This cluster perhaps consists of older participants who are taller and heavier, yet their intake of main meals, water, and vegetables is above average, and technology use is below average.

These clusters describe different lifestyles and dietary patterns that are associated with different obesity levels and therefore underline the need for individually targeted interventions and strategies in public health.

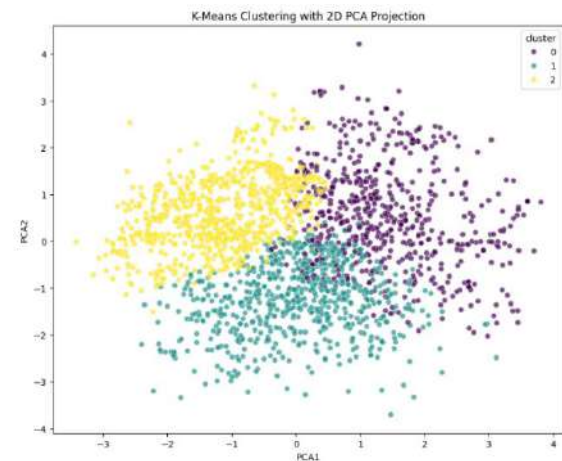


Figure 7. Cluster Analysis

It visualizes three clusters of data points in a two-dimensional space. The color of the points

is different to indicate that each of them belongs to one of the clusters.

E. Regression

The study used regression analyses, which have been run in the search for any probable or percentile linear relationships between variables. Again, these models were not primarily discussed but provided further insight into what determines factors of obesity.

Mean Squared Error: The value obtained for your regression model amounts to 2.929902797689109. The MSE is an average of the squares of the errors—that is, the average squared difference between predicted and actual values. The lower the MSE, the better the model fits the data.

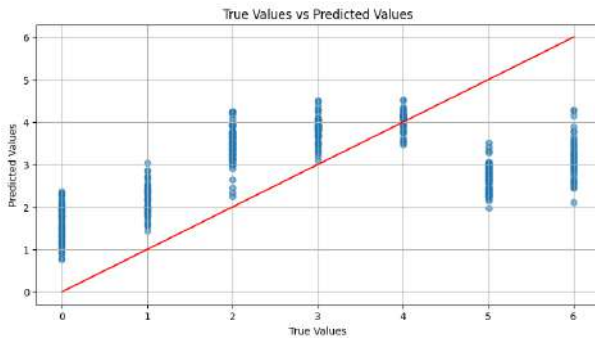


Figure 8. Regression Model Analysis

This graph plots the true values of a variable against the predicted from a machine learning model. In the graph, the data points will be below the diagonal line, which represents an underestimation of the real values by the model.

F. Target Variable Analysis

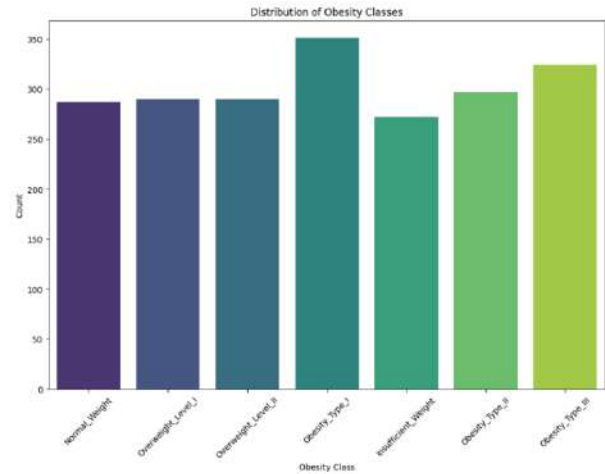


Figure 9. Target Variable Analysis

The graph illustrates the distribution of classes of obesity in the United States. The y-axis is 'Count,' while the x-axis is 'Obesity Class.' There are six data categories: Insufficient Weight, Normal Weight, Overweight Level I, Overweight Level II, Obesity Type I, and Obesity Type II. The chart entitled 'Distribution of Obesity Classes' actually represents a type of frequency distribution, where the frequencies for each category in the dataset are explicitly shown. Observations from that graph show that the most frequent weight category is 'Normal Weight,' followed by 'Overweight Level I.' People in a very small percentage fall in the category of 'Insufficient Weight.' The count increases gradually from the categories of overweight to obesity, thus proving that obesity is indeed a serious health issue in America.

The study's research gap: RF classifier had the best performance in terms of accuracy, and from the analysis of the correlation matrix, a number of important relationships among the variables have been obtained. There is a fair positive relation between age and weight, with a correlation coefficient of 0.202560, showing increased weight with age but not a very strong relationship. On the other hand, height and weight are positively correlated, having a value of 0.463136, or moderate, which would make sense because the taller a person is, the heavier they are.

Apart from that, the moderate positive correlation between height and NCP can be seen as 0.243672, which may denote that taller people might eat more main meals; nevertheless, this correlation is still relatively weak. There was a moderate negative correlation of -0.296931 between age and TUE,

probably meaning that the younger the age, the more time is spent with technology devices, reflecting lifestyle differences across age groups.

Other variables are poorly correlated, with a low linearity between them. For example, FCVC and weight maintain a value of 0.216125, which is very low. This means increased intake of vegetables has only a minor relation with an increase in weight, which can likely be altered by other factors.

Height and age may predict weight since their correlations were fairly at a medium intensity. On the same note, TUE is also to be predicted because of its negative relationship with age. In contrast, FCVC, NCP, and CH2O are poor predictors of weight or other parameters because their correlations are low or nil.

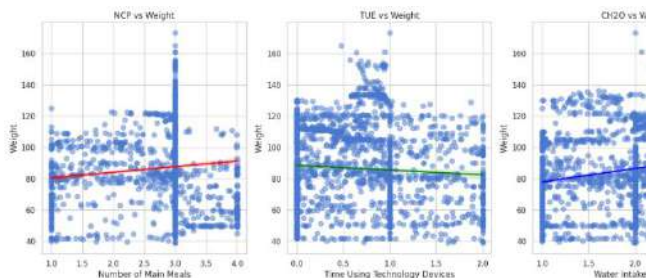


Figure 10. Target Variable Analysis

Scatter plots in this Figure examine the dependence on weight of three variables NCP, TUE, and CH2O.

Scatter plot of NCP vs weight: A very weak positive correlation between NCP and weight indicates that the more the number of meals, the more the weight showed a slight tendency to rise.

TUE vs. Weight: From the scatter plot, there is a weak negative correlation between TUE and weight. This, in turn, can be said to mean that with an increase in the time spent using technology devices, weight will slightly decrease.

CH2O vs. weight: This scatter plot shows that water intake - CH2O vs. weight comes along with a remarkable reduction in weight since there is a strong negative correlation depicted here.

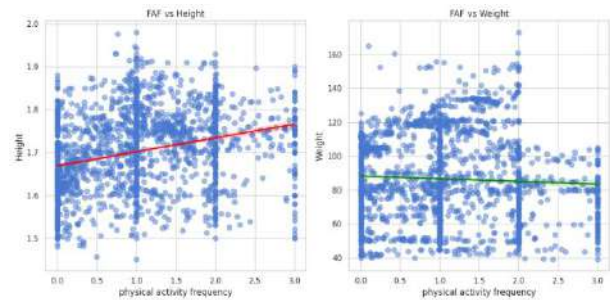


Figure 11. Target Variable Analysis

FAF vs. height: This scatter plot indicates a very weak positive correlation of frequencies of physical activity with height-that is, the greater the frequency of the activity, the slightly taller the tendency of height.

FAF vs. weight: One can tell from the scatterplot that the correlation between frequency of physical activities and weight is very poor with a negative relationship.

CONCLUSION

In this research, an overall success rate was obtained in the application of various machine learning techniques to predict and analyze the levels of obesity. The results as given by the Random Forest model were very promising and it turned out that these models were very strong on the obese classification task. Further research in this area would aim at refining these models and further exploration of datasets for a higher predictive accuracy. These insights are very important and go a long way in developing effective public health interventions and strategies against obesity.

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ID 361

Modelling Night Occupancy of Domestic Tourists in the Colombo District of Sri Lanka

KMUB Konarasinghe1#

Abstract— Domestic tourism is an important segment to ensure the sustainable development of the tourism industry in Sri Lanka. Colombo district marked the second-highest domestic occupancy in the country. This study was focused on forecasting occupancy guest nights of domestic tourists in the Colombo district of Sri Lanka. Monthly data of domestic guest nights from January 2008 to December 2020 were obtained from the Sri Lanka Tourism Development Authority (SLTDA). Sama Circular Model (SCM), Seasonal Auto-Regressive Integrated Moving Average (SARIMA) and Holt's Winter's three parameter models were tested. The Autocorrelation Function (ACF) and the Anderson-Darling normality test were used for model validation. The results revealed that the SCM satisfies the model validation criterion, whereas SARIMA and Holt's Winter's do not. It is concluded that the SCM is the best-fitting model for forecasting night occupancy of domestic tourists in the Colombo district of Sri Lanka. It is strongly recommended to forecast the night occupancy of domestic tourists in other districts as well.

Keywords – Sama Circular Model, Domestic Tourist, Night Occupancy

I. INTRODUCTION

Colombo district is located in the Western Province of Sri Lanka and it is the most economically significant and the most urbanized area of Sri Lanka, which accounts for the highest urban population (Dona, et al., 2023). The district lures with more than 20 natural and cultural landscapes with other tourism attractions. It is the second highest domestic tourist night occupancy district in Sri Lanka (SLTDA, 2021). "Domestic tourism [is] defined as the activities of a resident visitor within the country of residence, either as part of a domestic tourism trip or part of an outbound tourism trip" (UNWTO, 2008). Domestic tourism is also another segment that ensures sustainable development of the country.

I. Problem Statement

The behavior of the night occupancy of the domestic tourist in Colombo district shows an increasing trend with fluctuations up to year 2019, with a sudden drop up to May 2020 and recovery signs afterwards (Figure 1).

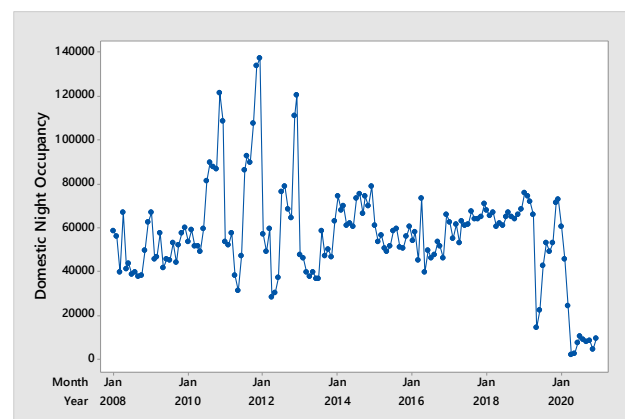


Figure 3. Time series plot of domestic night occupancy in Colombo District

Domestic tourism was the best product to maintain the tourism industry in Sri Lanka under situations of travel restrictions for international tourists (Karunaratne et al, 2021). Examining the future behavior of the night occupancy of domestic tourist is an essential guide to improve the performances of the tourism industry. It can be achieved by accurate forecasting (Schwartz and Hiemstra 1997). Nevertheless, the attempts were very less on forecasting domestic night occupancy in Colombo district in Sri Lanka. Hence, this study was design to fill the empirical and methodological gap.

B. The objective of the study

To forecast night occupancy of domestic tourists in the Colombo district of Sri Lanka.

C. The significance of the study

The results of this study can be used as a guide for strategy and policy development to ensure sustainable development of tourism industry in Sri Lanka.

II. LITERATURE REVIEW

Literature revealed that univariate and multivariate time series techniques were used in forecasting hotel room occupancy rates and guest nights. Brannas and Nordstrom (2000) have forecasted the number of Norwegian guest nights in Swedish hotels and cottages. They used Integer-valued autoregressive model. The Autoregressive Moving Average (ARMA) and Seasonal Autoregressive Integrated Moving Average (SARIMA) were used to forecast tourist accommodation demand in New Zealand by Lim, Chang and McAleer (2009). In Sri Lanka, Nishantha (2008) has modelled international tourist demand for Southern Coast using the SARIMA model. The SARIMA and Decomposition methods were used for forecasting foreign guest nights in Colombo and

Greater Colombo by Konarasinghe (2017-a). The SARIMA was used for forecasting foreign guest nights in Southern Coast and Ancient Cities of Sri Lanka (Konarasinghe, 2017-b; Konarasinghe, 2017-c). The Decomposition, Holt-Winters and SARIMA methods were used for forecasting foreign guest nights in Hill Country of Sri Lanka by Konarasinghe (2018). The Sama Circular Model (SCM) and SARIMA were used for forecasting foreign guest nights in Anuradhapura of Sri Lanka by Konarasinghe (2020). The latest patterns of night occupancy of international tourists in the Kandy district and the Southern Coast of Sri Lanka were forecasted by Konarasinghe (2023-a and 2023-b), wherein the SCM and SARIMA models were successful. Brannas and Nordstrom (2000), Lim, Chang and McAleer (2009) confirmed that the Integer-valued autoregressive, ARMA and SARIMA models are suitable for forecasting guest nights. In the Sri Lankan context, SCM and SARIMA performed extremely well in forecasting occupancy of foreign guest nights. It was confirmed by Nishantha (2008) and Konarasinghe (2017-a; 2017-b; 2017-c; 2018; 2020; 2023-a; 2023-b).

III. METHODOLOGY

Monthly data on night occupancy of the Colombo district for the period from January 2008 to December 2020 was obtained from the SLTDA database. The pattern of the night occupancy paves the path for model selections. Time series plots, Auto Correlation Functions (ACF) and Partial Auto Correlation Functions (PACF) were used for the pattern recognition (Konarasinghe & Abeynayake, 2014; Konarasinghe, 2016). According to the pattern of night occupancy of domestic tourists, the Sama Circular Model (SCM), the Seasonal Auto-Regressive Integrated Moving Average (SARIMA) and the Holt's Winter's three parameter models were tested. ACF and the Anderson-Darling normality test were used for model validation (Konarasinghe et al., 2015). Both relative and absolute measurements of errors were used to assess the forecasting ability of the model (Konarasinghe et al., 2015). The measurements of errors are; Mean Absolute Percentage Error (MAPE), Mean Square Error (MSE), and Mean Absolute Deviation (MAD) (Konarasinghe et al., 2015).

D. Sama Circular Model (SCM)

The Sama Circular Model is,

$$(1-B)^d Y_t = \sum_{k=1}^n (a_k \sin k\omega t + b_k \cos k\omega t) + \varepsilon_t$$

(1)

Where, B is the Back Shift operator; $BY_t = Y_{t-1}$,

and the d^{th} order difference is, $Y_t^d = (1-B)^d Y_t$

E. Seasonal Auto Regressive Integrated Moving Average (SARIMA)

An ARIMA model is given by:

$$\phi(B)(1-B)^d y_t = \theta(B)\varepsilon_t$$

Where; $\phi(B) = 1 - \phi_1 B - \phi_2 B^2 \dots \phi_p B^p$

$$\theta(B) = 1 - \theta_1 B - \theta_2 B^2 \dots \theta_q B^q$$

(2) ε_t = Error term

D = Differencing term

B = Backshift operator ($B^a Y_t = Y_{t-a}$)

Analogous to the simple SARIMA parameters, these are:

Seasonal autoregressive - (Ps)

Seasonal differencing - (Ds)

Seasonal moving average parameters - (Qs)

Seasonal models are summarized as

ARIMA (p, d, q) (P, D, Q)_s

Number of periods per season - S

$$(1 - \phi_1 B)(1 - \phi_1 B^S)(1 - B)(1 - B^S)Y_t = (1 - \theta_1 B)(1 - \theta_1 B^S)\varepsilon_t$$

(3)

F. Holt's Winter's three parameter Model

$$L_t = \alpha (Y_t / S_{t-p}) + (1-\alpha) [L_{t-1} + T_{t-1}]$$

(4-1)

$$T_t = \beta [L_t - L_{t-1}] + (1 - \beta)T_{t-1}$$

(4-2)

$$S_t = \gamma (Y_t / L_t) + (1 - \gamma) S_{t-p}$$

(4-3)

$$\hat{Y}_t = (L_{t-1} + T_{t-1}) S_{t-p} \quad (4-4) \quad \text{Where,}$$

L_t = is the level at time t , α is the weight for the level, T_t = is the trend at time t , β is the weight for the trend, S_t = is the seasonal component at time t , γ is the weight of the seasonal component, p = is the seasonal period,

Y_t = is the data value at time t ,

\hat{Y}_t = is the fitted value, or one-period-ahead forecast, at time t .

Formulae of Winter's additive model is;

$$L_t = \alpha (Y_t - S_{t-p}) + (1 - \alpha) [L_{t-1} + T_{t-1}] \quad (5-1)$$

$$T_t = \beta [L_t - L_{t-1}] + (1 - \beta) T_{t-1} \quad (5-2)$$

$$S_t = \gamma (Y_t - L_t) + (1 - \gamma) S_{t-p}$$

$$\hat{Y}_t = L_{t-1} + T_{t-1} + S_{t-p} \quad (5-3)$$

$$(5-4)$$

Where,

L_t = is the level at time t , α is the weight for the level, T_t = is the trend at time t , β is the weight for the trend, S_t = is the seasonal component at time t , γ is the weight of the seasonal component, p = is the seasonal period, Y_t = is the data value at time t , \hat{Y}_t = is the fitted value, or one-period-ahead forecast, at time t .

IV. RESULT

The analysis consists of two parts;

- 1). Pattern recognition of night occupancy
- 2). Forecasting of night occupancy

1). Pattern recognition of night occupancy

Figure 1 is the time series plot of night occupancy of domestic tourists from January 2008 to December 2020. The behaviour of the night occupancy shows a minor trend of increasing with fluctuations. ACF of

Figure 2 shows the trend and seasonal with the weak stationary.

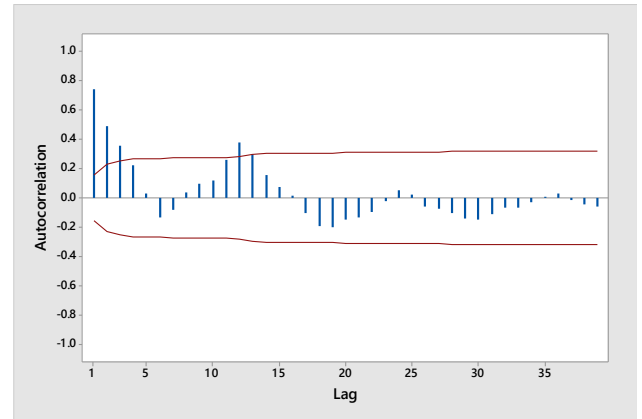


Figure 2. ACF of domestic night occupancy

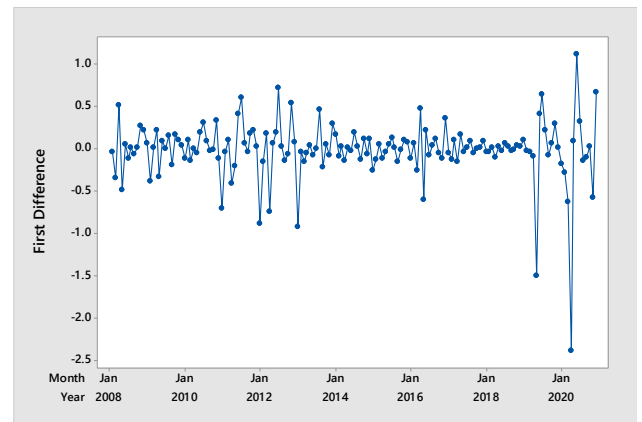


Figure 3. First Difference of Night Occupancy

The series of night occupancy contains seasonal behaviour with trends and wave-like patterns. Figure 3 is the first difference series of night occupancy, it shows a wave-like pattern. These behaviours can be captured by SCM, SARIMA and Holt's Winter's three parameter models. Hence, these models were tested.

2). Forecasting of night occupancy

The SCM, SARIMA and Holt's Winter's three parameter models were tested. SARIMA and Holt's Winter's models were not successful, as they did not satisfy the model validation criterion. SCM is successfully fitted, and it satisfies the model validation criterion.

Table 1. Model Fitting of SCM

Model	Model Fitting	
	MAPE	1.52615
	MAD	0.16630
	MSE	0.04472
	Normality	P = 0.481

$Y_t = Y_{t-1} - 0.0723 \sin \omega t$ $- 0.0728 \sin 3.25 \omega t$ $- 0.1410 \sin 5.25 \omega t$ $- 0.0927 \sin 6.5 \omega t$ $+ 0.1071 \cos \omega t$ $- 0.0913 \cos 2.75 \omega t$ $- 0.0954 \cos 5.25 \omega t$	Independence of Residuals	Yes
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The results of the Table 1 revealed that there were 7 significant trigonometric series out of 56. They are: $\sin \omega t$, $\sin 3.25 \omega t$, $\sin 5.25 \omega t$, $\sin 6.5 \omega t$, $\cos \omega t$, $\cos 2.75 \omega t$, $\cos 5.25 \omega t$.

The model satisfied the validation criterion. Residuals of the model were normally distributed and independent under the fitting process shown in Table 1. Besides, measurements of errors were low under the model fitting and verification. It was greater under the verification process shown in Tables 1 and 2.

Table 2. Model Verification of SCM

Model	Model Verification	
$Y_t = Y_{t-1} - 0.0723 \sin \omega t$ $- 0.0728 \sin 3.25 \omega t$ $- 0.1410 \sin 5.25 \omega t$ $- 0.0927 \sin 6.5 \omega t$ $+ 0.1071 \cos \omega t$ $- 0.0913 \cos 2.75 \omega t$ $- 0.0954 \cos 5.25 \omega t$	MAPE	3.15187
	MAD	0.31121
	MSE	0.23156

Figure 4 is the actual vs. fits of night occupancy obtained from SCM. The patterns of actual vs fits of night occupancy of domestic tourists are identical. Deviations among them had been very few.

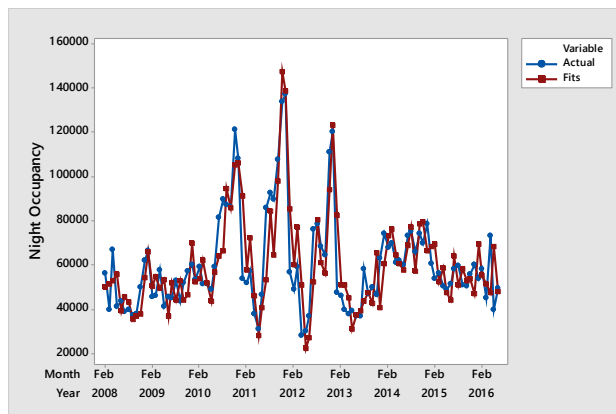


Figure 4. Actual Vs Fits of Night Occupancy

Figure 5 is a significant trigonometric series of $\sin 3.25 \omega t$ in SCM. The plot shows two seasonal lengths of 5 and 6 months of night occupancy of domestic tourists in the Colombo district.

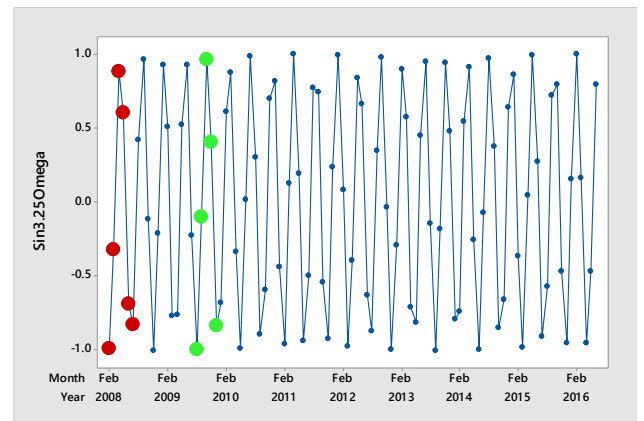


Figure 5. Plot of $\sin 3.25 \omega t$

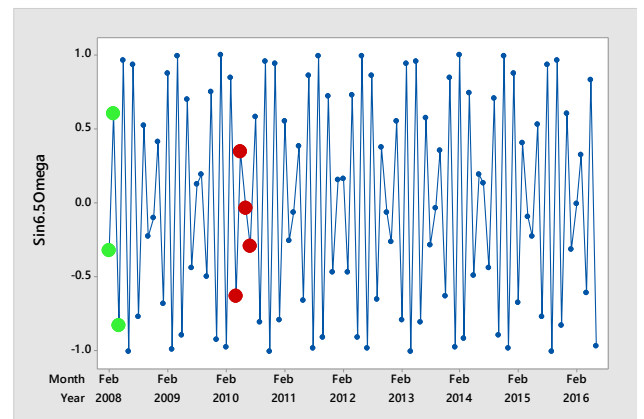


Figure 6. Plot of $\sin 6.5 \omega t$

Figure 6 is a significant trigonometric series of $\sin 6.5 \omega t$ in SCM. The plot shows two seasonal lengths of 3 and 4 months of night occupancy of domestic tourists in the Colombo district.

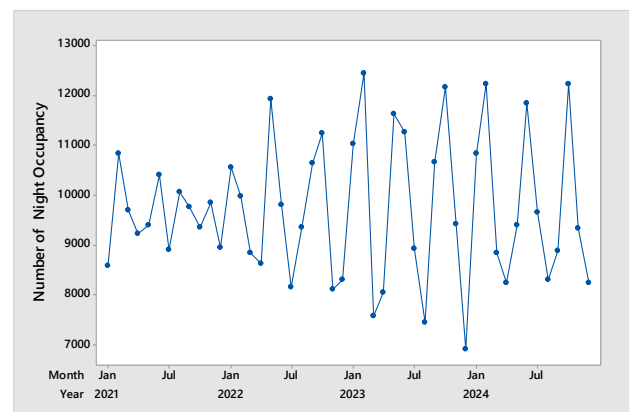


Figure 7. Forecast of Night Occupancy

Figure 7 shows the forecast of night occupancy for the period from 2021 to 2024. The behaviour of the night occupancy of domestic tourists in the Colombo district shows forced type oscillation. There is an improvement in domestic tourist activities in the Colombo district in Sri Lanka.

V. CONCLUSION AND DISCUSSION

The study concluded that SCM is the suitable model for forecasting domestic guest nights in the Colombo district in Sri Lanka.

The results of this study can be used to forecast the number of domestic occupancies in Colombo district. This is useful for strategy development of tourism-related business of transportation, accommodation, food and beverages, entertainment and other tourism-related activities in Colombo district in Sri Lanka. Business organizations can decide on new product developments and the rate of manufacturing by observing the occupancy behaviour. They can plan for various promotional offers and pricing strategies for their product and services based on the results of this study. Financial controllers in the tourism-related business can acquire knowledge to have a broad view of the cash/ credit flow of the company.

This leads to ensuring the well-being of society through improving the tourists' lifestyles. Ensuring the safety and security of the tourist is an important aspect of social well-being. Authorities can activate safety and security measures by observing the results of this study.

There could be negative and positive consequences in the Colombo district due to the increasing occupancy. This leads to tourism and could cause severe damage to the environment. The results of this study could minimize the negative impacts of environmental pollution. Developing strategies related to garbage recycling is another essential requirement. It can be imposed effectively by observing the results of this study.

It is strongly recommended to design more studies on forecasting domestic night occupancy in other districts, as it leads to the development of domestic tourism in Sri Lanka.

The data used for this study is from 2008 to 2020. It is hard to find night occupancy data after 2020. It is the main limitation of effective forecasting.

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A Study on the Relationship between Language and Non-Verbal Modalities such as eye contact, body gestures and facial expressions in a Bilingual Classroom at A Sri Lankan University

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Abstract

This study investigates the relationship between language and non-verbal modalities in a bilingual classroom at a Sri Lankan university. The central research question examines the existence and nature of the relationship between language and other modalities, including eye contact, body gestures, facial expressions, and contextual factors in communication. Employing qualitative research methodology, the study focuses on group discussions among a group of undergraduates at a Sri Lankan university, capturing the dynamic nature of bilingual interactions. The thematic analysis serves as an analytical lens, providing insight into the multiple dimensions of language and non-verbal dynamics in different communicative contexts based on two different discussions, one on an academic topic and the other on a general topic, which was video-recorded and meticulously observed using a predefined observation checklist. The findings of this study show that the students used non-verbal cues align with the language in their communication, which are subtle communication patterns that reveal the simultaneous influence of non-verbal cues and contextual factors in their communication. In academic discourse, participants grapple with linguistic complexities such as the expression of

complex ideas and cultural influences expressed in group project dynamics. On the other hand, discussions on the general topic revealed the delicate balance between the academic discussion and the general discussion, emphasizing the powerful influence of language contexts on personal interactions. This study contributes to the developing body of literature on bilingual communication elements by providing insights into the interconnectedness of language and non-verbal modes in the context of a Sri Lankan university. The findings have implications for improving communication strategies in bilingual educational settings. This study gives ELT instructors, instructors, policymakers, curriculum developers as well students insights into how to make language communication more effective with psycholinguistics aspect.

Keywords: Non-Verbal Modalities, Language, Bilingual Communication, Thematic Analysis, Context in communication

Introduction

1.1 Research background

In the ever- evolving landscape of education, bilingual classrooms have emerged focal points for comprehending intricate dynamics of communication. Language is one of the most important communication methods which includes a large set of sounds and symbols that are used by people. Communication can happen both verbally and non- verbally. Language can differ from the geographical area and people of that particular area. Non-verbal communication refers to the transferring of information through modalities such as body language, facial expressions, gestures, and eye contact according to the context of the communication and it plays a significant role in the education field. But in addition to that, these modalities can be used in other classrooms as well and this project aims to find out a relationship between language and these modalities such as gestures, eye contact and the context in communication.

1.2 Specific research focus

For humans, the ability to communicate and use language is not only in the verbal modality but also in the non-verbal modality. The term nonverbal communication was introduced in 1956 by psychiatrist Jürgen Rusch and author Weldon Keyes in the book "Nonverbal Communication: Notes on the Visual

Perception of Human Communication (Richard, 2020). The non- verbal communication can happen in several ways such as hand gestures, eye contact, body signs, and facial expressions (Galletti et al., 2020). These non-linguistic modalities mostly used by people with physical disabilities such as deaf and dumb but even in the regular situations people use non-linguistic modalities to communicate instead of the language (Morgan, 2015). When it comes to one particular field, the language and its inherent non-linguistic features can be recognized according to their context of communication. One of the major non-linguistic modalities is gestures. Gestures refer to a fundamental element of language that contributes meaningful and unique information to a spoken message. It reflects the speaker's underlying knowledge and experience (Clough & Duff, 2020). Also, a gesture benefits communication for speakers and listeners as well as its important cognitive functions for organizing spoken language and facilitating tasks such as problem solving, learning and memory (Clough & Duff, 2020) According to Kusanagi (2005, p. 386), "gestures provide more redundant or complementary input to the speech...when a gestural explanations succeeds, students understand the new language well, and as a result their better understanding may increase their

motivation and learning”. It is an innate and important element of social cognition which facilitates language acquisition more effectively. However, it is not essential for the development of language and joint attention (Galletti et al, 2020). As mentioned above, these gestures, eye contact and facial expressions are used to communicate with people instead of using a language. Therefore, these non-verbal modalities play a significant role in the communication. In the classroom settings, it can use some techniques to promote non-verbal communication. Especially in English language teaching (ELT) classrooms, students use these modalities without using additional language and it will help their peers’ cognitive development as well (Clough & Duff, 2020). Also, the relationship between language and gestures especially in bilingual settings, provides insights into the ways in which non – verbal communication supplements language learning. (Gullberg, 2006)

1.3 Significance of the study

The significance of investigating the relationship between language and various modalities, including gestures, eye contact, facial expressions, and contextual elements in communication within bilingual classrooms, stems from the pressing need to understand the

complex dynamics of language acquisition and interaction in diverse communication settings. Bilingual classrooms, characterized by students with distinct linguistic backgrounds, pose unique challenges and opportunities for effective communication. The incorporation of non-verbal modalities in the study of language is motivated by the recognition that communication is a multifaceted process, extending beyond mere linguistic exchanges. Non-verbal cues, such as eye contact, gestures and facial expressions, play a pivotal role in conveying meaning, especially when linguistic diversity is prevalent. By unravelling the intricate relationship between language and these modalities, we gain insights into how learners navigate and negotiate communication in bilingual environments. This research is motivated by the desire to enhance pedagogical practices and contribute to the development of communication strategies that address the complexities inherent in bilingual classrooms. Understanding the interplay between language and non-verbal elements is crucial for educators, policymakers, and researchers seeking to create supportive learning environments that cater to the diverse linguistic and cultural backgrounds of students in today's globalized educational landscape. The main objective of this research is to

identify the relationship between language and other non – verbal modalities such as eye contact, body gestures, facial expressions and context in communication in a bilingual classroom in Sri Lanka.

1.4 Route map

Embarking on an exploration of the intricate relationship between language and non-verbal modalities in bilingual classrooms within Sri Lankan universities, this research paper is organized into five chapters, the first chapter deals with the introduction and the background, objective and the significance of the study. The second chapter includes review of related theoretical literature, review of empirical literature, implication of the review for the study and conceptual framework with the summary of existing literature which includes subtopics as eye contact, body gestures and facial expressions and the communication contexts. Also, it includes the research gap and the research questions as well. Similarly, the third chapter includes the research methodology with context of the study and the participants, and the data collection instruments as classroom observations and video recordings and the data collection tool and techniques. Data analysis is part of the methodology chapter which is analysed qualitatively based on a thematic analysis. Then the fourth chapter presents the analysis of

the results and the interpretation of results discussion. The last chapter which is fifth chapter concludes the study derived from the findings and further research recommendations.

Literature review

2.1 Introduction

In the context of bilingual education, the relationship between language and nonverbal modalities such as eye contact, body gestures, facial expressions, and the context in communication in a bilingual classroom emerges as a central area of study. This descriptive chapter of the literature review delves deeply into the relationship and the interactions that exist between language and nonverbal cues such as gestures, eye contact, facial expressions, and the contextual

differences that can be seen in a bilingual classroom. Considering the constantly changing educational framework, which is characterized by linguistic diversity, this review methodically looks at a multitude of scholarly literature. All these different viewpoints show how language and non-linguistic modalities such as eye contact, body gestures and facial expressions interact dynamically, in different communication contexts by highlighting the need for in-depth comprehension when interpreting different communication interactions.

Effective communication in bilingual classrooms depends on the relationship between verbal and non-verbal modalities in addition to the oral language. This review explores the body of research literature on how language functions in a bilingual classroom setting in relation to other modalities like gestures, eye contact, facial expressions and context which help to look at how these nonverbal cues affect for the understanding, engagement, and general communication of bi-lingual learners.

2.2 Reviewing literature

2.2.1 Verbal Communication

Verbal communication involves the direct use of spoken language, encompassing the creation of sound patterns and the organization of vocal symbols produced by speech organs. It serves as a means to

convey ideas, emotions, and messages. Verbal communication is different from written language and it relies on the oral expressions of language. According to Khan (2001), verbal communication needs the use of language, which is a systematic collection of labels representing approximations of space-time events. Language can be conveyed through various means, including vocalization and writing as defined in different contexts. The process of verbal communication is highly regulated and reinforced by significant formal and informal learning (Harris, 2002, p. 153). The use of language is limited to verbal communication. The concept of communication is the interaction between people. Verbal communication is way to communicate for people. Some of the key components of verbal communication are sound, letters, words, speaking and a language. As we know language is the communication of sounds, patterns, words which conveys the meaningful information. Human being is differing from others due to the capacity of verbal communication. Varshney (2003) states that “language is a systematic verbal symbolism; it makes use of verbal elements such a sound, words, and a phrase, which are arranged in certain ways to make sentences. Language is vocal in as much as it is made up of

sounds which can be produced by the organs of speech”’.

2.2.2 Nonverbal Communication.

Nonverbal communication refers to a wide range of behaviours and cues that convey messages without the use of words. This includes body gestures, facial expressions, eye contact, posture, and other non-linguistic modalities that contribute to the overall communication process (APA, 2020). Language is not the source of communication, there are another means also non- verbal cues which is important though often neglected aspects of communication. The most obvious example of non-verbal communication, and one that most people think of first is body gesture, eye contact and facial expressions. However, non-verbal communication takes a number of forms as above. An understanding about non-verbal communication can improve the effectiveness of communication. Gregersen (2007) states; Communication takes various forms, one of which is oral or speech. However, when people communicate, they usually do more than just utter words. Furthermore, they also use their hands (gesture), head movement, eye (eye contact), lips (smile), bodily postures and symbols to communicate which always accompany oral discourse-intended or not. The impact of these non-linguistic cues in conversation is called non-verbal communication. It includes

'the messages other than words that people exchange'. There are not any clear-cut linguistic structures for non-verbal communication. On the other hand, Nonverbal communication conveys messages that go beyond language (as cited in Negi, 2009, p.101). In a word, nonverbal communication has fewer rules than verbal communication and is judged more by situational variables than by absolute correctness of behaviour. Andersen (2007) stated categorized non-verbal communication into several types. Those are: Kinesics, this type of this nonverbal communication includes: facial expressions, body language, gesture, eye contact, and appearance. Touches (Haptic), human communicate a great deal through touch and people can communicate messages or convey language by given a weak handshake, a warm bear hug, a condescending thump on the head, or a controlling grip on the arm. Although these non-verbal modalities can differ depending on the culture, the situation, and the closeness of the relationship. Someone can use physical space to communicate many different nonverbal messages, including signals of intimacy and affection, aggression, or dominance. Voice (Paralinguistics) refers to vocal communication that is separate from actual language. This includes factors such as tone of voice, intonation, stress,

loudness, inflection, and pitch (Smith, ND). Consider the powerful effect that tone of voice can have on the meaning of a sentence as well.

2.2.3. Body gesturers and language

Gestures, which include , eye contact , hand movements, facial expressions, and body gestures, are essential in bilingual classes. (McNeill ,1992) found that gestures can act as an additional channel for communicating meaning, especially when linguistic competence in both languages is limited. In these kinds of circumstances, gestures assist with bridging language proficiency gaps by providing indications of visual movement that improve language comprehension. Furthermore, Kita and zyürek (2003) discovered that gestures can improve vocabulary development, with students in bilingual classrooms frequently employing gestures to clarify and strengthen their spoken responses. Bilingual students have distinct gesture patterns for each language, which reflects the influence of cultural and linguistic environments (Goldin-Meadow, 2003). Nonverbal communication is important in language instruction, according to researchers (Gardner & Wagner, 2004). Body gestures emerge as a powerful strategy for bridging language gaps in the context of ELT, where learners are frequently struggling with language acquisition.

Nonverbal cues, such as body gestures, can help to improve comprehension and the overall conversational experience (Kumaravadivelu, 2006). In both monolingual and bilingual classrooms, using gestures into instruction (particularly for mathematical topics) can increase learning (Alibali & Kita, 2012). Gesture creation can help bilingual kids with comprehension and expression in their emerging languages by acting as a scaffolding tool. (Joshi ,2010) did a mixed method research on "Gestures in the ELT Classroom." by using a qualitative data collection method and the classroom observations done by generating codes through a thematic and ethnographic analysis. The major purpose of the study was to determine which gestures are most regularly used in ELT classrooms and the impact of the gestures towards the learners. He employed twenty secondary-level English teachers and their students. When the teachers pointed quickly with their fingers, the students felt embarrassed, and the teachers furrowed their brows in answer to questions. Many studies have investigated whether gestures influence listeners' comprehension of speech. These include studies using video clips as stimuli (Kelly & Church 1997) and studies in which listeners view or participate in "live" interactions (Goldin-Meadow et al 1999, Goldin-Meadow & Sandhofer 1999,

Holler et al 2009). Across some studies, there is strong evidence that gestures affect listeners' comprehension of speech. When gestures express information that is redundant with speech, they contribute to successful comprehension (Goldin-Meadow et al 1999, McNeil et al 2000). Gestures can detract from listeners' direct uptake of information in speech when they express information that is not expressed in speech (Goldin-Meadow & Sandhofer 1999), yet they frequently communicate vital information in their own right. Gestures play a crucial role in human communication because they energize talks, explain misconceptions, and express strongly felt emotions. Gestures are classified into three types by Roger E. Axtell (1998, p4): instinctive, coded, and acquired. Instinctive motions are those that we perform subconsciously and unconsciously. When a person crosses his or her arms, for example, it is frequently a show of defensiveness. When people are surprised or shocked, they tend to hit the back of their heads unconsciously. This type of gestures is the most universal of all. Lee and Chen (2019) discovered that students who actively used gestures during group discussions in ELT settings had better levels of participation. Furthermore, the researchers discovered a link between regular use of gestures and gains in language proficiency among the

participants. More specialized gestures are coded or technical gestures. Smith and Brown (2016) conducted an observational study focusing on the relationship between teacher gestures and student engagement in ELT group discussions. The results suggested that teachers who utilized a diverse range of gestures were more successful in capturing students' attention and maintaining a dynamic and engaging classroom environment. They can be compared to jargon or specialized vocabulary in verbal language. Acquired gestures are socially generated gestures. They differentiate societies and communities. The origins of these gestures are difficult to pinpoint. The "OK" sign and the hand wave as in Hello or Goodbye are two examples. The link between these movements and their meaning, like that of words, is frequently arbitrary. These gestures typically outnumber the others.

2.2.4. Eye contact and communication dynamics

Eye contact is another nonverbal modality that plays a significant role in bilingual classrooms. According to Pfeiler (2009), appropriate eye contact can convey concentration, engagement, and comprehension, promoting a pleasant atmosphere in the classroom and

facilitating more effective communication. Understanding the impact of eye contact in ELT group discussions is crucial for creating an engaging and communicative learning environment. However, cultural norms might affect the dynamics of eye contact in multilingual classrooms because different students may have different ideas about what constitutes appropriate eye contact. In multilingual classroom conversations, investigate the function of eye contact in turn-taking, feedback sharing, and participation regulation. Investigate how cultural norms influence eye contact and communication habits. Improve your grasp of nonverbal communication cues in a variety of cultural circumstances. In bilingual classrooms, encourage culturally aware teaching strategies that facilitate successful communication (Gudykunst & Kim, 2003). Develop interventions to address challenges related to misinterpretations of eye contact cues. Eye contact is not only just to communicate or interact with others. It helps to boost up confidence students as teachers in class try to make eye contact with each and every student. While making eye contact students feel secure and valuable. Moreover, students who feel shy to express, feels superior, leading in class because of eye contact. Roger, Diane & Steve (2004) cited, “a teacher who never looks students in the eye

seems to lack confidence and gives the students a sense of insecurity.” Johnson and Lee (2019) discovered a relationship between teacher-student eye contact and student involvement in ELT group discussions. According to the findings of the study, students who received frequent eye contact from teachers were more likely to actively participate in conversations and showed higher levels of interest in the subject matter. In a study published in 2020, Garcia and Kim investigated how eye contact promoted group cohesiveness in ELT environments. According to the study, students who made mutual eye contact during group talks felt a better feeling of belonging and collaboration, which led to a more cohesive learning environment. Moreover, A study conducted by Li and Park (2016) examined the relationship between eye contact and verbal fluency in ELT discussions and discovered that students who maintained constant eye contact with their classmates demonstrated improved verbal expression and fluency. According to the findings, eye contact may operate as a facilitator of successful verbal communication skills.

2.2.5.Facial expressions and language comprehension.

Emotions are powerfully represented on the human face. Recognizing and interpreting these signs is important in

social interaction because it influences how to comprehend people, respond to their feelings, and navigate interpersonal relationships. A large corpus of research has been conducted to investigate the intricate relationship between facial expressions and emotional comprehension. Happiness, sorrow, anger, fear, surprise, and disgust were named as generally recognized basic emotions by Ekman (1967). Each emotion presents a distinct configuration of facial muscle movements, readily decoded by humans across cultures (Darwin, 1872). This multimodal approach allows students to navigate the complexities of bilingualism more effectively and enhances comprehension by providing additional layers of meaning. The amygdala, a key brain region for processing emotions, lights up when we view emotional expressions, suggesting an innate neural basis for this ability (Adolphs, 2002). Understanding the intricacies of emotional expression necessitates taking into account context, cultural variations, and individual differences. A raised eyebrow, for example, can indicate surprise or even flirtation depending on the situation (Jack et al., 2014). Cultural standards also influence how emotions are expressed and interpreted (Matsumoto, 2010). Individual characteristics such as age, gender, and neurocognitive ability can also influence emotional recognition

accuracy (Tottenham et al., 2009). Park and Smith's (2018) qualitative investigation explored the connection between facial expressions and linguistic difficulty in ELT group conversations. Results showed that students' facial expressions varied with language complexity, indicating that facial cues dynamically adapt to the nuances of the language of the discussion. Facial expressions serve as a nonverbal modality for language comprehension, emotional engagement to linguistic complexity, and the establishment of the rapport between learners. Despite these complexities, research reveals the crucial role of facial expressions in fostering empathy and building successful social relationships. Accurately reading emotions allows us to respond with compassion, support, or appropriate action, enhancing social communication and building trust (Izard, 2014). The link between facial expressions and emotional understanding is multifaceted and ever evolving. While universal recognition mechanisms exist, context, culture, and individual differences play vital roles in deciphering the emotional landscape of the human face. Garcia and Kim's (2019) qualitative thematic data analysis brought to light the complex relationship between language understanding and facial expressions in ELT settings. According to the study, students' facial expressions frequently

reflected how well they understood the language, adding a further level of communication that enhanced in comprehension and interaction. Li and Wang (2016) carried out a qualitative study to investigate the effect of cultural backgrounds on facial expression interpretations. The results highlighted cultural differences in the manner in which students noticed and reacted to facial expressions in ELT settings. This investigation highlighted how important it is for teachers to take cultural differences into account when interpreting facial expressions in language discussions.

2.2.6. The relationship between language and nuances of Context in Bilingual Communication

Analyse how specific classroom contexts (subject matter, group activities, small group interactions) influence the use and interpretation of non-verbal cues in bilingual communication. Rodriguez and Gomez (2017) employed thematic data analysis method to examine the subtle differences in nonverbal cues used in multilingual conversation in various settings. The results showed that the cultural and situational context had a substantial impact on how body language, facial emotions, and eye contact were interpreted. This emphasizes the

significance of considering context-specific meanings when interpreting nonverbal communication. Form the development of context-aware teaching strategies that meet the different demands of bilingual learners by improving student participation and engagement in various classroom contexts—including the physical space and situational cues—has a big impact on how well students communicate in multilingual learning environments. Researchers like Gumperz (1982) have emphasized the significance of comprehending sociocultural context in communication, and bilingual classrooms are frequently rich in varied cultural backgrounds. Furthermore, emphasizing the context's vital role in communication within bilingual classrooms, it can affect the language choice, how gestures are understood, and whether eye contact is suitable. The interaction between language and non-verbal modalities such as gestures, eye contact, and contextual cues is crucial for effective communication. Understanding and harnessing these interactions can improve students' language learning experiences, promote intercultural understanding, and facilitate more successful communication in these complex educational settings. The pragmatic roles of nonverbal modalities in multilingual communication were examined in a qualitative study by Patel

and Martinez (2016). Thematic data analysis revealed that body language, facial expressions, and eye contact performed a variety of non-linguistic activities, such as cues for turning, agreement or disagreement, and turn-taking signals. These results highlight how crucial nonverbal cues are to efficient bilingual conversation.

2.3. Summery and Research gap

According to the literature review, there are much research was done by many experts, and they have produced different opinions regarding the relationship between the language and other modalities such as gestures, eye contact, facial expressions and context in communication in bilingual classrooms around the world. Much research has been done based on the learners o and teachers and how these non-linguistic modalities are used in language learning and teaching process. While previous research has explored the complex relationship between language and non-verbal communication in bilingual classrooms, a significant gap exists in understanding this phenomenon within the specific context of Sri Lankan universities. Existing studies primarily focus on Western educational settings, overlooking the nuanced interplay of cultural and linguistic factors present in

Sri Lankan classrooms. Therefore, further investigation is crucial to address the following research gaps: Lack of studies in Sri Lankan university settings: The distinctive cultural and linguistic dynamics inherent in developing nations like Sri Lanka's educational environments have been largely ignored in research on nonverbal communication in bilingual classrooms. Analysis of specific non-linguistic aspects is limited: Although some research has examined at the function of body gestures, facial expressions and eye contact in various contexts, more research is required to fully understand how these particular characteristics appear in Sri Lankan bilingual classrooms and how it impacts to the communication among bilingual learners. In order to communicate effectively in these situations, it is imperative to investigate how these modalities are interpreted and used culturally. Unclear relationship between language, body gestures, eye contact and facial expressions and context in communication: Despite existing research acknowledging the interconnectedness of these elements, further exploration is needed to clarify the specific nature of this relationship within Sri Lankan university classrooms among bilingual learners. How do factors like subject matter, student background, and language proficiency influence the use and

interpretation of non-verbal cues. Addressing these research gaps will provide valuable insights into the intricacies of communication in Sri Lankan bilingual university classrooms. Through this, we can develop culturally sensitive pedagogical practices and improve the learning experience for diverse student populations. Also, some researches are done for the kinds who are in age between 1-3 years on how these kids communicate with gestures and eye contact without verbal communication. Most of this research is done in European countries and there is less amount of research done in South Asian countries, especially in Sri Lanka. Also, they have not covered people who are in pre-intermediate level age between 20-25. And there is another area which some researchers are only focusing on the first language communication rather than focusing on the second language and foreign language. Therefore, I have found that there is a research gap between above mentioned areas. This leads to an important research gap: The Research Gap: While existing research acknowledges the importance of non-linguistic features in language communication, there is a dearth of studies exploring their interplay in bilingual classrooms like those found in Sri Lankan universities. Students can explore how language, gestures, eye

contact, facial expressions and context interact to shape verbal communication in the academic and general settings where they move between Sinhala and English.

2.3 Research questions

The human face offers a captivating window into the world of emotions, with facial expressions playing a key role in social interaction and emotional understanding. While Ekman's (1967) identification of six universal basic emotions laid the groundwork, research highlights the intricate interplay of context, culture, and individual differences in deciphering this emotional landscape. Beyond facial expressions, however, non-linguistic cues like gestures and eye contact further enrich our understanding of emotions. Yet, research in this area often focuses on single cultures or contexts, overlooking the complexities of bilingual settings like Sri Lankan universities.

To address the research gap, this study proposes the following research questions:

1. What is the relationship between non-linguistic features (gestures, eye contact, facial expressions) and language

influenced in bilingual classrooms in Sri Lankan universities? This question delves into how the dynamic interplay of Sinhala and English impacts the use and interpretation of non-verbal cues within the classroom environment. Examining how language affects body gestures and eye contact will provide valuable insights into the nuanced communication within these multilingual settings.

2. Is there a relationship between language and body gestures, eye contact and context in communication with the university students who learn English language in Sri Lanka? This question probes deeper, exploring how the specific context of learning English interacts with non-verbal cues. Do students exhibit distinct gestural and eye contact patterns and facial expressions while they are in two different communication contexts. This study will investigate into these interactions specifically, on the understudied dynamics of non-verbal communication in bilingual classrooms, offering valuable insights into how language, gestures, eye contact, and context collaborate to shape communication and emotional understanding in Sri Lankan universities.

Chapter III

3. Methodology

Methodology is a systematic procedure of a specific study which needs to achieve the pre-determined objectives. Research methodology is a way to solve research problems very systematically. This chapter incorporates design / context of the study, population, sample and sampling strategy, research tools, resources of data, data collection procedures and ethical consideration.

3.1 Context

The research data was collected within a bilingual university in Sri Lanka, within this context, English is the primary medium of instruction for higher education, while Sinhala, the native language for most of the students which continues to hold significant social and cultural weight. This creates a dynamic setting where students navigate between two languages, potentially influencing their communication patterns and non-verbal expressions. Universities in Sri Lanka typically follow a traditional lecture-based approach, with limited opportunities for interactive learning and student participation. The role of non-verbal modalities in the classroom, with gestures, facial expressions and eye

contact potentially playing a compensatory role in supplementing limited verbal interaction among students. Therefore, the contextual factors and the bilingual setting, verbal and on verbal interaction between students – becomes vital role for interpreting the data collection of this study. It allows for a more nuanced understanding of how non-verbal features like gestures, facial expressions and eye contact function within different communication contexts and specific environment, enriching the analysis and contributing to a comprehensive picture of communication in Sri Lankan university classrooms.

3.2 Participants

This study involved 07 participants, composed of both male and female at a university in Sri Lanka. All the students were enrolled in English language programs, representing various years of English learning experience ranging from 13 years. The population of this study was 07 undergraduates of 1st year in a university in Sri Lanka. They were selected as sample by using purposive non random sampling procedure. Their proficiency levels varied, with categorized as intermediate to upper intermediate. Regarding their L1, 06 participants identified Sinhala as their primary language, there was only one participant whose L1 was Tamil who

were reflecting the dominant bilingual context of the university setting. This participant composition, encompassing students' comprehensive examination of non-verbal communication dynamics within the bilingual university classroom environment.

3.3 Data instruments.

This study employed a multi-layered qualitative data collection method that combined classroom observations and video recordings to comprehensively explore the interplay of non-verbal communication in bilingual university classrooms. This approach ensured rich data capture, allowing for both real-time analysis and detailed observations of subtle non-verbal cues based on an observation checklist. The research tool was a classroom observation and video observations of the group discussions among selected undergraduates . The study was based on both primary and secondary sources of data. The primary sources were used for collecting the data though the observations and the check list and the secondary sources were used to facilitate the study from previous literature.

3.3.1. Classroom Observations:

At the core of this study based on a systematic classroom observation. The researcher is the one who observe the

group discussions equipped with pre-designed checklists, focused on three key non-verbal communication variables as follows:

- Eye contact: The frequency and direction of eye contact between students were meticulously recorded, noting variations during the discussions and individual interactions.
- Body gestures: The type and intensity of gestures used by students were documented, paying particular attention to changes associated with language switching, emotional expression, or specific interaction patterns during the group discussions.
- Facial expressions: The range and nuances of facial expressions displayed by participants were video recorded, considering the context of classroom interactions.

The checklist also incorporated note sections to capture instances of non-verbal behaviour and interactions that deviated from typical patterns. Observations were done according to two different discussion topics, one as a general topic and other one is an academic topic. These two discussions aimed to achieve a comprehensive picture and the relationship between language and of non-verbal

communication within the bilingual environment.

3.3.2. Video Recordings:

To delve deeper into select interactions and facilitate detailed analysis, video recordings were conducted of two different classroom discussions. This enabled researchers to revisit crucial moments, providing opportunities for frame-by-frame observations of key interactions and nuanced non-verbal cues that might have been missed during live observations. Video recordings proved invaluable for analysing the real-time dynamics of emotional expression and communication flow within the bilingual classroom. By combining these two qualitative data collection methods – systematic observations and video recordings – this study aimed to identify the relationship between language and non-verbal communication within the bilingual university classroom environment. This multi-layered approach provided valuable insights into the interplay of eye contact, body language, and facial expressions, enhancing our understanding of how participants navigate communication and express emotions and behaviours in this unique setting.

The primary sources of data were total number of the students, and the data was

collected through ethnographic observation through classroom observation and video recordings. Mainly data was collected through the classroom observation and checklist which used to help to focus the attention on the sample and how did they use eye contact, body gesturers and the facial expressions throughout their discussions.

The secondary source of data was collected through the consulted books, thesis, articles, journals, reports, and World Wide Web (WWW) to facilitate the study. Some of the secondary sources were Harmer (2008), Lyons (2006), Young voices in ELT (2006), journals of NELTA (1999, 2003, and 2006) and Robinson (2010).

3.4 Research design and data collection.

The research design of this study adopted to explore the “role of non-verbal communication and the relationship between language and the non-verbal modalities such as gestures, facial expressions and the eye contact in two different the context of communication in ELT classroom”. The research design was conducted ethnographic observation research design to achieve the objective of the study. Ethnographic research designs are the qualitative research

procedures for describing, analysing, and interpreting a culture-sharing group’s shared patterns of behaviour, beliefs, and language that develop over time [Hammersley & Atkinson \(2007\)](#). This research provides an in-depth insight into the user’s views and interactions along with the sights and sounds they encounter during their discussions. It provides an understanding of how those users see the language in different contexts and how they interact with peers around them. In this design where the researcher selects specific discussion topics related to two different contexts as academic related topic and general topic and administers the language and the non-verbal gestures with a standardized form of observation checklist. Ethnography is the method, which is used in ethnographic fieldwork are observing, asking questions, participating in group activities, and testing validity against intuition Spradley (2016). Collecting data or information from the individuals or in a group. The collected data was analysed descriptively with the help of different ways such as direct and indirect observation and checklist. Therefore, ethnography is very useful method to collect the data in a specific and small population to discover and find their usage of non-linguistic features such as eye contact, body gestures and facial expressions their behaviours between or among the people.

Therefore, in this research study the researcher chose to adopt an ethnographic observation research design to fulfil the objective of this study.

The data collection procedure was done based on the checklists which is attached in appendix one. This was focused on the non-verbal cues used by the participants in the sample. The checklist was attempted by the observation of the participants in the ELT classroom discussions. The process of data collection was as follows: Firstly, the checklist was designed to observe the participants while they were in their group discussion. After that, got the permission to observe and video record the undergraduates as well as to involve them for data collection by signing a consent form from the participants. The two different topics were assigned participants for their discussion which represent two different contexts for their discussion. First one was 'Academic work at the University' which is an academic topic and the second one was 'love and relationships' which is related to general topic and assigned them 20 minutes per each topic. Then the classroom observation was conducted while the discussion and the same time, the discussion was video recorded for further observations.

3.5 Data analysis

In this study data was analysed and interpreted descriptively based on classroom discussion observation, video recorded observations and the checklist. Group discussions of the participants were analysed according to the check list. Furthermore, data was analysed and interpreted in accordance with participants' both verbal and nonverbal proficiency in the different contexts of their discussions based on a thematic analysis and an ethnographic analysis.

Thematic analysis is a method for analysing qualitative data that comprises reviewing the information for patterns to establish central themes (Braun & Clarke, 2006). The researcher's own subjective experience is at the core of the active, reflexive process of data interpretation. ethnography is a qualitative data collection method which often used in the social and behavioural sciences (Pink, 2013). Data are collected through observations and interviews, which are then used to draw conclusions about how societies and individuals' function in their social interactions.

3.5.1. Analysing Classroom Observations:

The data from structured classroom observations was analysed through a thematic analysis approach. Initial codes were utilized according to the pre-

defined checklist variables in eye contact, body gestures, and facial expressions. After initial coding, an iterative process of identifying and refining themes was used. The coder reviewed the observation notes and discussed recurring patterns, identifying emerging themes that captured the nuanced interplay of nonverbal cues in the bilingual classroom. This iterative process of theme identification and refinement continued, with ongoing discussions and revisions ensuring the coder's reliability and the construction of a robust thematic framework. Emergent themes were rigorously reviewed by ensuring they were grounded in the data, internally coherent, and distinct from one another. Additionally, sub-categories emerged organically within broader themes, offering further nuance and detail. For example, within the theme "Cultural Influences on Gesture Usage," a sub-category might focus on "nodding the head when agreeing on something," highlighting how students adapt their non-verbal agreement with their peers based on their cultural backgrounds and language choices in a different context in communication.

3.5.2. Analysing Video Recordings:

Video-recorded classroom sessions underwent a focused thematic analysis as well as ethnographic analysis by focusing on the behaviours of using gesturers and eye contact in a group discussion. Primarily targeting specific interactions identified during the observation stage. This detailed analysis allowed for frame-by-frame examination of subtle non-verbal cues and temporal dynamics of emotional expression. Facial expressions, fleeting micro-gestures, and shifts in eye contact could be meticulously analysed, offering deeper insights into unspoken interactions and emotional communication within the bilingual context.

Thematic analysis of the video recordings served as a powerful complement to the analysis of classroom observations. The two group discussions were identified as particularly rich in nonverbal interactions were examined frame by frame. This in-depth analysis allowed for a fine-grained examination of subtle cues and temporal dynamics of emotional expression. Instantaneous micro gestures, changes in eye contact intensity, and subtle shifts in facial expression, easily missed during live observation, can be captured and analysed, enriching the understanding of nonverbal communication in a bilingual context. Insights gained from video analysis which is served to refine and

validate themes identified through classroom observations, creating a comprehensive and nuanced picture of nonverbal communication patterns such as eye contact, body gestures and facial expressions. Categorization of information emerged organically through the iterative coding process. Recurring patterns and shared characteristics within themes led to the formation of subgroups that provided further nuance and detail. For example, within the theme "Cultural Influences on Body Gestures", a subcategory titled "Emphasis and Clarifying Gestures" may emerge, where students use specific hand gestures to emphasize points or clarify meaning when switching languages between Sinhala and English to highlights the manner during their group discussions.

By combining rigorous thematic analysis with the complementary strengths of both live classroom observations and video recordings, this study was able to delve deeply into the unspoken language of non-verbal communication based on eye contact, body gestures and facial expressions, on its unique role in navigating the bilingual university classroom environment. Employing a rigorous thematic analysis approach and ethnographic analysis, informed by both classroom observations and video recordings, this study delved deeply into

the non-verbal tapestry woven within bilingual university classrooms. By systematically coding data, identifying emergent themes, and organically categorizing information, the analysis revealed the intricate ways in which students and instructors utilized and interpreted non-verbal cues to navigate communication, express emotions, and facilitate learning within this unique educational setting. This multi-layered approach to data analysis provided a robust framework for understanding the unspoken language of the classroom, shedding light on its crucial role in shaping communication and interaction within the bilingual university environment.

3.6 Ethical considerations

The ethical considerations have very important values in the research field. Every respondent has their right to privacy. They should be informed the purpose of the study and value of their participation on research. Therefore, in the process of collecting primary and secondary data as well as in analysing and interpreting the data, all the ethical issues have been considered. In order to maintain the ethical ness and validity of research, researcher will not harm the authentic source in the time of data collection; researcher will take the

permission from the concerned authorities and participants by signing a consent form from the participants. The identities of the participants will keep anonymous, and they will not hurt physically, physiologically, socially and economically. Bad and negative aspects of participants will keep safely. Similarly, to avoid the plagiarism, and intellectual theft, researcher have mention proper citation and references for making the research more and more authentic and real. On the basis of collected data the results will derive, and it will discuss in terms of developing the participants.

Chapter 04:

Results and discussion

This chapter incorporates the analysis and interpretation of the collected data. For this study, the data were collected by using the qualitative data collection tools such as classroom observation, video recordings and a checklist and analysed based on a thematic analysis. Researcher mainly used the descriptive approach to analyse under, analysis and interpretation of data. This chapter investigates the interplay of language and nonverbal communication, revealing the relationship between language and

nonverbal cues in the context of student interactions at a Sri Lankan University. Using extensive observational and video data, the data was investigated how students build up interaction between verbal language and nonverbal modalities under 3 variables as , eye contact, facial expression, and the body gestures. Through this in-depth exploration, it aims to identify the relationship between language and the nonverbal cues that shape communication and enrich the learning experience in the bilingual setting. The results and findings will be discussed here according the variables and codes generated through the thematic analysis.

4.1 The relationship between the language and eye contact in context in communication.

Especially when considering bilingual students in Sri Lankan colleges, the connection between language and eye contact becomes apparent as a critical component of communication. A careful and attentive keeping of eye contact was seen throughout participant behaviour throughout thematic analysis of their academic conversations. Maintaining this degree of eye contact throughout the discussion highlights how important nonverbal clues are for communicating interest and active participation in the

academic topic. The general theme discussion of love and relationships, on the other hand, revealed a subtle difference in eye contact that was impacted by the topic's intense emotional content. The participants' consistent maintenance of eye contact with various speakers during both discussions to facilitating of good communication and highlights the significance of nonverbal cues in creating a favourable environment for conversation. These results are consistent with previous research, which emphasizes the importance of eye contact in promoting engagement and guaranteeing effective communication in educational environments (Gudykunst & Kim, 2003). Furthermore, Matsumoto's (2006) theory of subliminal nonverbal cues that may be present in conversations addressing emotionally charged issues is consistent with the observed fluctuation in eye contact during discussions on sensitive subjects, such as love and relationships. All things considered, this study clarifies the complex connection between language and eye contact, highlighting its many functions in influencing the dynamics of communication between bilingual students in a classroom.

4.2 The relationship between language and Body Gestures in different communication contexts:

As findings based on the thematic analysis in *table 01* and *table 02*, Nodding the head was a common gesture during both academic and general discussions, particularly when expressing agreement as follows,

“ ‘Yeah, that’s called self-love. Tell us about self-love.’ – general topic

“I totally agree. It’s fascinating how morphology helps us break down words into meaningful units.” – academic topic

As mentioned in above quotes, in both situation other participants were nodding the head to express the agreement to the speaker and without saying anything they use body gestures to respond to the speakers. Body language was often used to indicate agreement and highlight key ideas, including nodding and hand gestures. According to Kendon (2017), nodding is a nonverbal recommendation that enhances the positive dynamics of discussions. Strategically used hand gestures draw attention to specific parts of the language, supporting studies on the significance of gestures in highlighting important ideas in a communication. (McNeill, 2005). Also, Hand gestures were used to address important matters that required focused attention, emphasizing the significance of certain points.

'I think syntax is crucial in understanding how words are arranged in a sentence.' - academic topic

"It was so toxic like I had to prove that wherever I am I have to send a picture." – general topic.

In this situation the speaker used hand gestures to highlight the importance of the details and to grab the attention from others. By using hand gestures, the speaker can add more significant to the language depending on the context. This indicates that learners perceive an existent semantic and pragmatic relationship between the content of speech and gesture, in line with previous research (McNeill 1992; Cassell et al. 1999). Pointing finger gestures were used to highlight and emphasize specific aspects of the conversation in both contexts. While explaining some concepts in Sinhala, participants employed expansive, emphatic gestures, seemingly amplifying their verbal expression. This aligns with Morris' (1971) research on cultural variations in gestures and suggests a reliance on non-verbal cues to supplement meaning in their native tongue.

4.3 The relationship between language and Facial Expressions in the Group Discussion:

In Sri Lankan university classes, the relationship between language and facial expressions was presented through video recordings of group discussions. Smiles and relaxed eyebrows during emotional moments indicated confidence and comprehension, echoing Darwin's (1872) research on universal expressions of happiness. The findings of the thematic analysis presents that facial expressions aligned with the emotional tone of spoken language in both academic and general discussions.

"So yeah I went to counselling as well and my family supported me a lot to recover. It's not actually...." – general topic

the speakers emotions were aligned to the facial expressions and the tone was very low and others pay attention to her story.

Participants used a range of facial expressions such as smiling, happiness, sadness, open mouth (surprise), and raised eyebrows (curiosity, interest) specially in the general topic which is about love and relationships. They were more comfortable and showed interest to the topic and therefore, they showed many facial expressions during their group discussion on the general topic. But in the academic related topic they talked about the subject matters and there they didn't showed much facial expressions

because they were talking about something that they were very serious.

“ Understanding linguistic theories is crucial, but the practical application of these theories in diverse classroom settings is equally important.”

Expressions such as smiling, open mouth, and raised eyebrows were observed in English, contributing to the expressive nature of communication and there were various facial expressions observed in the general discussion.

‘Yeah, that’s called self-love. Tell us about self-love. What do you do for self-love?’

‘Wait are you talking about your ex?’ – general topic.

Facial expressions were critical in conveying emotional nuances in both academic and general contexts. Aligning facial expressions with spoken language enriches communication and is consistent with research that highlight the importance of facial expressions in conveying emotions (Ekman, 2009). The participants' intended communication is further enhanced by the employment of particular facial expressions like raised eyebrows, an open mouth, and smiling. The correlation between language and facial expressions highlights the relationship between nonverbal and

verbal communication. According to Matsumoto and Willingham (2009), the usage of facial expressions in English enhances language expression and understanding overall.

This result emphasizes how context can affect emotional expression and nonverbal modalities, which is consistent with Matsumoto's (2010) emphasis on the cultural context of nonverbal communication. Overall, the video observations showed how participants employed nonverbal cues to navigate language interactions in this bilingual classroom in Sri Lankan University. It was a dynamic relationship between language and facial expressions within the group discussions among participants.

4.4 Language, Context, and Non-Verbal Cues:

Thematic analysis of classroom observations revealed a dynamic interplay of non-linguistic features within the bilingual university setting. **Eye contact patterns** shifted noticeably based on language usage. Students displayed increased direct eye contact when discussing about the general topic which was aligning with cultural norms of respect and directness. This finding resonates with literature by Mehrabian (1971), highlighting the cultural

dependence of nonverbal communication. A strong relationship emerged between language, body gestures, eye contact facial expressions , and specific communication contexts. During discussions, participants tended to use expansive gestures and maintain direct eye contact while explaining complex concepts for potential comprehension difficulties. This finding supports Krauss et al. (1996) on the use of gestures for pedagogical clarity and suggests participants awareness of the impact of the contexts that bilingual students faced. In the Informal discussion which is on the general topic, participants displayed more relaxed postures, more gestures, and a more dynamic flow of eye contact. This aligns with Argyle & Cook (1976) on non-verbal communication in informal settings and suggests a focus on conversational engagement and mutual understanding over linguistic precision in a bilingual classroom setting in a Sri Lankn university. This can be caused due the **cultural influences** with language and the context. Participants were regardless of the language used, highlighting the cultural norms even within the bilingual environment. This finding resonates with Matsumoto (2010) on the importance of cultural context in nonverbal communication and suggests a discussions between language demands

and cultural identity within the bilingual classroom.

4.5 Thematic analysis

4.5.1 General Topic.

Variable	Utterance	Language
Eye contact	<p><i>Love is really hard. Even though it's right, you can't....'</i></p> <p><i>But really that's like... you love your family so you need to... you have their blessings and stuff.</i></p> <p><i>We were good friends. Not just friends. Like we were good. At the beginning we were talking.....'</i></p> <p><i>'That's the point. Tell me why you are not like trying to start a relationship with anyone. Give us a hint.'</i></p>	English
Facial Expressions	<p><i>'Yeah, that's called self-love. Tell us about self-love. What do you do for self-love?'</i></p> <p><i>'Wait are you talking about your ex?.'</i></p>	English

	<p><i>'his family, he doesn't have his father. He died when he was pretty young. So his mother.....'</i></p> <p><i>So yeah I went to counselling as well and my family supported me a lot to recover. It's not actually... I used to talk to myself because I couldn't control it all.'</i></p>		<p>Smiling, happiness, sadness</p> <p>Open mouth when expressing surprise and shock.</p> <p>Raising eyebrows when expressing surprise, curiosity and interest.</p>
Body Gestures	<p><i>'It was so toxic like I had to prove that wherever I am I have to send a picture.'</i></p> <p><i>'Yeah, that's called self-love. Tell us about self-love.'</i></p> <p><i>'Then you have to decide. What happens if you don't listen to your parents?'</i></p>	English	<p>Use hand gestures addressing important matters that require focused attention.</p> <p>Nodding head when agreeing.</p> <p>Pointing finger to emphasis something during the discussion.</p>

	Vari- able s	Utterance	Language	Codes generated	
In re sp on se to th e ini tia l re se ar ch qu est io n, ou r fin di ng s hi gh lig ht th e dy	Eye cont act	<p><i>‘let’s talk about our academics at the university’.</i></p> <p><i>‘I think syntax is crucial in understanding how words are arranged in a sentence.’</i></p> <p><i>‘What happened to the after-lecture classes?’</i></p> <p><i>And the other thing. Usually when x lecturer do lectures we had the recordings. And now we don’t have recordings.’</i></p>	English	<p>Frequency of eye contact with different speakers</p> <p>Maintains eye contact with others while expressing their ideas.</p> <p>Maintain eye contact with others when asking questions.</p>	<p>nami c intera ction betw een spok en and nonv erbal cues, highl ighti ng their signif icanc e in prom oting intera ction and clear com</p>
	Faci al expr essio ns	<p><i>‘I find phonology a bit challenging, especially the phonetic transcription part.’</i></p> <p><i>‘Maybe incorporating more practical exercises and group activities can help.’</i></p> <p><i>Understanding linguistic theories is crucial, but the practical application of these</i></p>	English	<p>Facial expressions align with the emotional tone of spoken language.</p> <p>Use facial expressions when</p>	<p>muni catio n. Base d on extan t resea rch,</p>

researchers investigate the subtle functions of facial expressions, body language, and eye contact in determining the tenor of scholarly and informal conversations. the second study question, clarifying how these nonverbal cues differ on context when learning English among Sri Lankan university students. The results highlight how language influences communication in educational settings and how language and nonverbal behaviour are connected and the dynamic role non-verbal communication plays in navigating bilingual university classrooms including the eye contact, body gestures, and contextualized communication. The relationship between language and nonverbal cues through thematic analysis, provides insightful knowledge about the communicative dynamics in bilingual education.

Chapter 05

Conclusion

In conclusion, this study explores the environment of bilingual education at Sri Lankan universities using two fundamental questions as: 1) What is the relationship between non-linguistic features (gestures, eye contact, facial expressions) and language in bilingual classrooms? and 2) Is there a relationship between language and other modalities such as eye contact, body gestures, facial expressions, and context in communication within a Sri Lankan university setting? By utilizing a symphony of classroom observations and video-recorded interactions, Rather, it interacts with nonverbal modalities throughout group discussions. The research firmly establishes the intimate relationship between language and context, demonstrating how non-verbal modalities amplify the meaning of language communication. In general, and academic contexts, dynamic changes in body gestures concerning language

variations generate a dynamic communicative landscape in which words line up with gestures, eye contact, and facial expressions shaped by cultural contexts in the classroom. It has significant implications for teaching and learning to acknowledge this work of literature. At the same time, a better understanding of the way nonverbal cues are translated between languages promotes efficient communication, which enhances bilingual education. This study is the initial step in a fascinating synthesis that encourages more investigation into the numerous and interconnected interactions between language and nonverbal modalities among bilingual learners in Sri Lanka.

Further research areas

- Investigate how these non-verbal cues interact with specific language skills like reading comprehension, writing fluency, or pronunciation in each language.
- The relationship between language and factors like posture, spatial proximity, and vocal intonation to paint a more nuanced picture of communication dynamics.
- Investigate teacher-student interactions: Analyse how teachers utilize non-verbal cues to support language learning and how students respond to these cues in each language.

- Explore how personality, cultural background, and prior language experience influence the use and interpretation of non-verbal cues.

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A Corpus-based Study of Linking Words used in Academic Journal Articles in ELT Journal and TESOL Quarterly

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Abstract— In the context of ELT, the current study attempts to investigate which linking words are the most and least frequently used in the ELT Journal and TESOL quarterly. Research articles published in journals by instructors or subject matter experts are referred to as scholarly articles, or academic journal articles. For the purpose of this study's corpus-based analysis, which is an efficient method of analyzing language data was utilized and a corpus was built with a total of 50 research articles published in TESOL Quarterly and ELT Journal. An analysis and identification of the usage of linking words in scholarly journal articles was conducted by loading the corpus into the LancsBox corpus tool with a total of 404887 tokens, the corpus was referred to as Corpus 12. The study examined 30 linking words in total and sought to answer two research questions regarding the most and least common linking word types as well as the linking words' usage. Results showed that "and" was the most frequent, while "thirdly" was the least. Additionally, "for," "or," "but," and "as" appeared frequently, whereas "until," "unless," and "firstly" were less common. Coordinate conjunctions emerged as the most prevalent type of linking words. Among six categories, information-adding linking words were the most commonly used. These findings provide valuable insights for educators on the use of linking words in academic writing and suggest further research on their application across various contexts.

Keywords: Corpus-based analysis, Linking words, Frequency, Journal articles, ELT, TESOL

I. INTRODUCTION

Academic prose refers to a distinct style of writing used in scholarly works such as theses, lectures, tutorials, and particularly academic research articles (Carter & McCarthy, 2006). The coherence and organization of such writings are influenced by

language preferences, style guidelines, and cultural norms (Elena, 2016). Writing with precision and discipline is essential, especially when preparing scholarly works for journal publication or dissertations. Unlike spoken language, which often involves simpler sentence constructions, academic writing features complex sentence structures with a range of syntactic features, highlighting the importance of coherence and cohesion.

A critical skill in academic writing is the effective use of linking words. These connectors help ensure smooth transitions between ideas and sentences, enhancing both the grammar and structure of a text. Linking words serve essential functions, such as expressing explanation, addition, contrast, sequencing, and reasons, which are all vital for maintaining textual coherence. Transition words play a pivotal role in helping sentences and paragraphs flow logically. The importance of linking words is also highlighted in corpus linguistics, where a corpus serves as a source of linguistic knowledge. Advances in technology have made it easier to compile, store, and analyze large-scale natural language corpora, which are used not only in linguistic research but also in language technology, including tools like word processors, spell checkers, and text summarizers (Qureshi & Haidov, 2020). In linguistics, corpora are instrumental in a variety of tasks, such as frequency counting, sentence analysis, and word sense disambiguation.

For second-language learners, mastering vocabulary and linking words is essential for developing independence in reading, writing, and comprehension (Matte & Sarmento, 2018). Nation (2013) underscores that building a large vocabulary is key to achieving linguistic autonomy, while Liu (2016) emphasizes the role of linking words in creating coherence between ideas. Swales and Feak (1994)

further classify linking words into subordinators, sentence connectors, and phrase linkers, highlighting their diverse functions in maintaining flow and cohesion in writing. Recent studies, such as those by Apse and Farneste (2018), offer more nuanced classifications of linking words, distinguishing between adverbials and conjunctions. The variety of terms used to describe linking words—such as "connective adjuncts" and "logical connectors"—reflects the complexity of their linguistic functions.

This study aims to explore the use of linking words in academic journal articles, specifically in the *ELT Journal* and *TESOL Quarterly*, two prominent publications in the field of English Language Teaching (ELT). Using corpus analysis, the research will identify the most and least frequently used linking words in these journals, as well as the types of linking terms that are prevalent in academic writing. The methodology includes sample selection, corpus compilation, data collection, and analysis procedures. The study's findings will be presented, detailing the most common linking words and their usage patterns, followed by a summary and suggestions for future research.

RQ 1: Which linking words are the most and least frequently used in academic journal articles in *ELT Journal* and *TESOL Quarterly*?

RQ 2: Which type/(s) of linking words are the most frequently used?

III. METHODOLOGY

1) Sample

The current study analyzes the use of linking words in a corpus of fifty scholarly research articles on English language teaching (ELT), drawn from two prominent journals: *TESOL Quarterly* and the *ELT Journal*. A total of twenty-five articles from each freely or openly accessible journal were selected. The sampling method employed was purposive sampling, also known as judgment sampling, which involves selecting a sample that is considered representative of the population (Gay et al., 2012). *TESOL Quarterly*, a peer-reviewed journal established in 1967, publishes articles relevant to English language teaching, learning, and standard English as a second dialect (WILEY Online Library, 2023). The *ELT Journal*, a quarterly publication, addresses issues related to English Language Teaching as a second, additional, or foreign language, and connects practical teaching concerns with knowledge from fields such as sociology, psychology, education, and applied linguistics (OXFORD ACADEMIC, 2023). The articles selected for this study cover a wide range of topics related to ELT, including the history of language learning, English Medium Instruction

(EMI), challenges in language teaching across different contexts, practical teaching implications, various teaching methodologies, translanguaging, the use of digital technology, teacher perceptions, and teacher well-being.

2) The corpora

To build the corpus for this study, the articles were saved and collected in Notepad form using the program "Notepad++." This free, open-source text editor for Windows supports various programming languages and allows users to work with multiple text files at once, making it useful for managing and organizing content (Notepad++, 2023). Researchers often compile corpora by extracting relevant text portions from sources like books, articles, and websites, while eliminating unnecessary HTML tags or metadata.

The saved data were then loaded into the corpus linguistic software *LancsBox* and labeled as "Corpus 12." *LancsBox* is a user-friendly program compatible with major operating systems that can compile new corpora or load data from existing ones, such as the British National Corpus (Andrushenko, 2023). It offers various tools for analysis, including KWIC, Graphcoll, Words, Ngrams, Wizard, Whelk, and Text. While *LancsBox* is effective for analyzing frequency and language patterns in large datasets, significant human interpretation is still necessary to meet the research goals (Hanane, El Biadi & Chatri, 2022).

3) Data collection method/(s)

I employed a document analysis as the data collection instrument in this study. Moreover, according to Bowen (2009), document analysis is a methodical process that involves examining and assessing written and digital materials (computer-generated and transmitted over the Internet). These materials comprise text and images that have been captured spontaneously by the researcher. One could argue that the investigation was carried out by the researcher using document analysis that contains text (word). There was no need to request permission through ethical documents to use the data from these two journals, as they are publicly available, for use in this study.

4) Data analysis

As mentioned above, the present study investigates two research questions and the data were analysed through a corpus-based analysis. The corpus for this study consists of 50 academic journal articles totalling 404,887-word tokens as shown in Table 1 below.

Table 1: Distribution of Corpus 12

Linking words	Frequency per 10k	Dispersion: 01_CV
1. Also	22.648294	0.427398
2. So	9.978093	0.741817
3. However,	8.718482	0.612570
4. Thus	5.137236	0.813883
5. Further	3.852927	0.886912
6. Therefore	3.556548	0.977418
7. Furthermore	1.531291	1.430933
8. Finally,	1.210214	1.040744
9. Next	1.185516	1.333209
10. Moreover	1.160818	1.381199
11. Hence	0.642154	2.615648
12. Firstly	0.321077	2.478480
13. Secondly	0.222284	3.474696
14. Unless	0.148189	3.246053
15. Thirdly	0.098793	4.965080

Language	No. of files	Tokens	Types	Lemmas
English	50 files	404,887	21982	19589

In this analysis, a set of linking words was selected to identify the most and least frequently used in academic research articles. The investigation involved two stages: determining which linking words were present in the corpus and analyzing their absolute frequencies. The language data from Corpus 12 were imported into the LancsBox tool, which facilitated an accurate count of linking word frequencies using the Word feature. This tool allows for the creation of frequency lists based on various settings, such as corpus selection, frequency type, dispersion, and unit (type, lemma, or parts of speech).

To focus on conjunctions, the type was filtered into lemma, and the code *_con was used to limit the search results to conjunctions only. The analysis also involved changing the frequency setting to relative frequency per 10k words while keeping dispersion

unchanged. As a result, the tool automatically sorted conjunctions from most to least frequent, and the filtered results were compiled in a table showing the conjunctions' frequencies.

The below *Table 2* and *Table 3* shows the difference of results that can be seen when the unit *Type* is changed into *Lemma* and *Table 4* indicates the filtered results from conjunctions.

Table 2: Words frequency with unit Type in Word feature (LancsBox)

Type	Frequency: 01 - Freq	Dispersion: 01_CV
the	19537.000000	0.183109
and	13615.000000	0.176035
of	13513.000000	0.159242
in	10259.000000	0.204447
to	8612.000000	0.203395
a	6176.000000	0.189926
for	4275.000000	0.246397

Table 3: Words frequency with unit Lemma in Word feature (LancsBox)

Lemma	Frequency: 01 - Freq	Dispersion: 01_CV
the_other	19350.000000	0.183257
and_con	13614.000000	0.176091
of_con	13513.000000	0.159242
@card@_other	11708.000000	0.366294
in_con	10242.000000	0.204429
be_v	10114.000000	0.200539
to_other	8612.000000	0.203395

*Table 4: Filtered results from Lemma (*_con) of linking words in the catalogue*

In addition, since some linking words were not counted among the conjunctions in the previous phase of the corpus analysis, the second phase of the analysis involved searching for a set of linking words selected from “Dictionary of Linking Words: A Guide to Translation Studies” (Cesur, 2018). In addition, the table created in the first phase of this corpus analysis has been updated with these selected linking words and their frequencies. In order to search the corpus and determine the frequency, a random selection of linking words from Dictionary of Linking Words was made.

Table 5: Selected linking words from Dictionary of linking words and their frequencies

Type	Linking words
Coordinate conjunctions	And, for, or, but, so
Subordinate conjunctions	Because, although, while, before, after, since, unless, until, whereas, as
Linking adverbials	Also, however, thus, further, therefore, furthermore, finally, next, moreover, throughout, Hence, alongside, firstly, secondly, thirdly

Through these two stages, a total of thirty linking words were selected for the analysis. In order to identify the most and least frequently used linking words from these selected lists, all thirty linking words were gathered into one table and the whole table was selected and sorted into descending order (Home>Sort). In addition to the identified relative frequency of the linking words per 10k, the normal frequency was also added into a column. The unit relative frequency was changed into *Frequency 01* in the Word feature to identify the frequency.

In order to respond to the second research question which is about identifying most frequently used linking words type, all these thirty linking words were categorized into several semantic groups of linking words based on the categorizations found on the previous studies. First they were categorized into conjunctions and linking adverbials as they are the two main types of 'linking words'. There are two

Type	Linking words00
numeration/Sequencing	firstly, secondly, thirdly, finally, next, until, after, before
Addition	Further, furthermore, moreover, also, and
Contrast	But, however, although, whereas, while
Results	Therefore, hence, thus, so
Reason	Because, as, for, since, or, unless
Space/location	Alongside, throughout

subcategories of conjunctions as coordinate and subordinate conjunctions (Zinkeová, 2023). The below Table 6 displays the categorization of all thirty linking words into coordinate, subordinate conjunctions and linking adverbials in order to

Linking word	Frequency – Relative frequency per 10k	Dispersion: 01_CV
1. And	336.241964	0.176091
2. For	105.585015	0.246397
3. As	78.491036	0.369486
4. Or	25.859067	0.487463
5. But	14.473174	0.543069
6. Because	9.780507	0.869293
7. While	7.829345	0.822379
8. Although	5.557106	0.796945
9. After	5.087839	1.154455
10. Before	3.136678	1.054449
11. Since	1.531291	1.135476
12. Whereas	0.963232	1.686184
13. Throughout	0.938533	2.129780
14. Until	0.691551	1.509252
15. Alongside	0.642154	1.804751

discover which type is most frequently used. On the other hand, they were again categorized into some semantic categories. Table 7 indicates how these thirty linking words are categorized and classified according to the classification methods used by Liu, (2008. As cited in Gunes 2017. P: 25), Kennedy, (1992. As stated in Liu et al., 2018, p. 190) and Biber et al. (1999).

Table 6: 1. Categorization of linking words in corpus into conjunctions and linking adverbials based on Zinkeová, 2023.

Table 7: 2. Categorization of linking words in corpus based on Liu, (2008. As cited in Gunes 2017. P: 25), Kennedy, (1992. As stated in Liu et al, 2018. P:190) and Biber, Conrad and Leech, (2002).

IV. RESULTS

1) Most frequently and least frequently used LWs

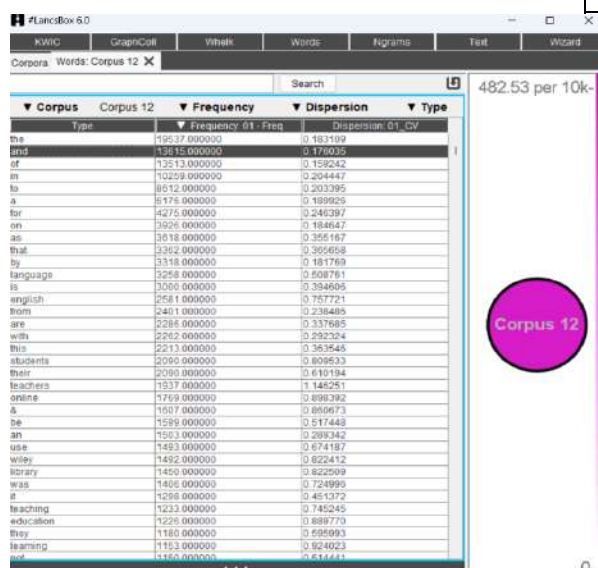
Here the Table 8 shows how above-mentioned LWs in the analysis were gathered into one table and sorted from descending order and how the results shows the most frequent and least frequent linking words

Table 8 – Sorted linking words on descending order.

By looking at the sorted data it can clearly identify that the LW ‘and’ has the highest frequency from all thirty linking words and it is the most commonly used LW as per the results. The frequency is 13615 and the relative frequency per 10k is 336.241964. Following ‘and’ the LWs ‘for’ and ‘as’ have the second and third highest frequencies. From these selected LWs, it is denoted that the LW ‘thirdly’ is the least frequently used LW and it is 0.098793 per 10k. Further it can be distinguished that the LWs that goes same with ‘firstly’ such as ‘secondly’, ‘firstly’ also have a low frequency.

Moreover, the LW ‘and’ is the second most frequently used word used within the whole corpora. The highest frequency of words in this corpus is 482.53 per 10k and the article ‘the’ has the highest frequency. In LancsBox corpus tool, in order to visualize the frequency of an item in the table in Word feature, right side of the table there is a feature with a circle which will change the shade of the circle according to the frequency value of an item. When click on a word with high frequency the shade changes to a dark colour and if the word has a low frequency it changes to a light colour. The scale on the right side of the circle shows a reference point for interpretation (Brezina, McEnery & Wattam, 2015) and Brezina, Timperley, Gablasova and McEnery, (in prep). The following figure shows how the colour of circle changes according to the most frequent LW ‘and’ and least frequent LW ‘thirdly’.

Figure 2: How the shade changes according to the frequency value of an item.



Linking word	Frequency	Frequency – Relative frequency per 10k	Dispersion: 01_CV
1. And	13615.000000	336.241964	0.176091
2. For	4275.000000	105.585015	0.246397
3. As	3618.000000	78.491036	0.369486
4. Or	1048.000000	25.859067	0.487463
5. Also	917.000000	22.648294	0.427398
6. But	592.000000	14.473174	0.543069
7. So	404.000000	9.978093	0.741817
8. Because	397.000000	9.780507	0.869293
9. However,	353.000000	8.718482	0.612570
10. While	321.000000	7.829345	0.822379
11. Although	225.000000	5.557106	0.796945
12. Thus	208.000000	5.137236	0.813883
13. After	206.000000	5.087839	1.154455
14. Further	156.000000	3.852927	0.886912
15. Therefore	144.000000	3.556548	0.977418
16. Before	130.000000	3.136678	1.054449
17. Furthermore	63.000000	1.531291	1.430933
18. Since	63.000000	1.531291	1.135476
19. Finally,	49.000000	1.210214	1.040744
20. Next	48.000000	1.185516	1.333209
21. Moreover	47.000000	1.160818	1.381199
22. Whereas	39.000000	0.963232	1.686184
23. Throughout	39.000000	0.938533	2.129780
24. Until	28.000000	0.691551	1.509252
25. Hence	26.000000	0.642154	2.615648
26. Alongside	26.000000	0.642154	1.804751
27. Firstly	13.000000	0.321077	2.478480
28. Secondly	9.000000	0.222284	3.474696
29. Unless	6.000000	0.148189	3.246053
30. Thirdly	4.000000	0.098793	4.965080

The results distinguish that the category of 'addition' which included the LWs of further, furthermore, moreover, also, and is the most frequently used linking words type and its total frequency is 14798. Such LWs are used to link the additional information within a sentence, at the beginning of a sentence or among paragraphs. For examples according to KWIC unit,

1. Those with general EAP as their aims.
Further, in order to focus on the most...
2. Issues of linguistic imperialism.
Furthermore, many recent studies...
3. Can be used to take a stance *and* develop voice in...

The second most frequent semantic category is LWs related with reasoning. Because, as, for, since, or, unless represented that category and LWs of indicating location or place showed the least frequency from the 6 groups.

V. DISCUSSION

1) RQ 1 - Which linking words are most and least frequently used in academic journal articles in ELT Journal and TESOL Quarterly?

The current study examined the use of linking words (LWs) in scholarly journal articles from *TESOL Quarterly* and *ELT Journal*, focusing on the frequency of various LWs. It found that words like "and," "for," "as," "or," "also," "but," "because," and others are the most frequently used, while words like "until," "hence," "unless," "firstly," and "thirdly" have the lowest frequency. This study provides unique findings, as previous research has not focused on an extensive list of LWs. For example, Matte and Sarmiento (2018) conducted a similar study comparing only linking adverbials between British and Brazilian Academic Written English (BAWE and BrAWE). Unlike most studies, which focus on specific semantic categories or a select few LWs, this research provides novel insights into LW usage across a broader range of LWs in academic articles.

2) RQ 2 - Which type(s) of linking words are most frequently used?

This study examines the frequency distribution of various types of linking words in scholarly journal articles, focusing on three main categories: coordinate conjunctions, subordinate conjunctions, and linking adverbials. The findings reveal that coordinate conjunctions are the most commonly used, followed by subordinate conjunctions, with linking adverbials being the least frequent. Coordinate conjunctions like "and" and "for" appear 19,530 times, indicating their role in connecting grammatically equal parts of sentences and enhancing textual coherence (Zinkeová, 2023). Subordinate conjunctions, such as "although"

and "because," occur 5,033 times, reflecting their function in creating dependent clauses and adding complexity to academic writing (Quirk et al., 1985, as cited in Zinkeová, 2023). Linking adverbials, including "therefore" and "however," appear 2,102 times, mainly used for transitions, contrasts, or causal relationships (Liu, 2008, as cited in Zinkeová, 2023). The study also found that addition linking words were the most frequently used type, appearing 14,798 times, followed by reason-related linking words (9,407 instances) and contrastive linking words (1,530 instances). The dominance of addition linking words highlights their importance in introducing new information and expanding ideas, while reason-related linking words, such as "because" and "since," play a key role in presenting logical arguments (Onwuegbuzie, 2016; Zinkeová, 2023). Contrastive linking words are essential for presenting opposing views, demonstrating the nuanced communication methods used in academic discourse. Other categories, such as enumeration (487 instances) and results (782 instances), also contribute to structuring scholarly writing, though less frequently.

VI. CONCLUSION

The study investigates the use of linking words (LWs) in scholarly journal articles related to English Language Teaching (ELT). It finds that coordinate conjunctions like "and," "but," "or," and "for" are the most frequently used LWs, while linking adverbs such as "firstly" and "thirdly" are the least common. The most prevalent LW category is information-adding words, surpassing those for sequencing, justifying, contrasting, or indicating outcomes. The research successfully identifies how LWs contribute to coherence and structure in academic writing. The study also highlights that different LWs serve varied functions in scholarly discourse, which can help both novice and experienced writers improve their academic texts. The methodology, which involved constructing a corpus and using tools like LancsBox, can be applied to future studies on academic writing. However, the findings are limited to ELT journals, and future research should explore LWs in other fields and consider linguistic and cultural variations.

The study recommends further research on the teaching and use of LWs in different contexts and suggests examining how well teachers and students understand and apply these tools. Overall, the research enhances understanding of how linking words shape academic discourse in ELT and offers valuable insights for educators and scholars to improve scholarly communication.

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This achievement highlights her dedication to advancing the field of TESOL and enhancing language learning experiences for students.

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GK Nayanathara is a dedicated student of language education. Currently pursuing a Bachelor of Arts degree in Teaching English to Speakers of Other Languages (TESOL) at the General Sir John Kotelawala Defence University. She has the honor of presenting the research findings at the esteemed DIELE research conference, IRC 2023, SLELTEC where she shared valuable insights on language acquisition and effective teaching methodologies.



An investigation into the influence of social media on fashion industry market dynamics in Sri Lanka: A study on the impact of Facebook and Instagram on the Apparel Industry

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Abstract

The rapid adoption of social media platforms, particularly Facebook and Instagram, in Sri Lanka has significantly transformed the fashion market. Traditional marketing strategies are deemed insufficient, necessitating a deeper understanding of how these platforms influence consumer behavior, brand loyalty, and market trends. This study explores the impact of Facebook and Instagram on traditional marketing channels, sales channels, customer engagement, and brand reputation in the Sri Lankan clothing industry. Utilizing social influence theory and consumer behavior theories, the research examines how fashion influencers, trends, and peer opinions on social media shape consumer attitudes, preferences, and purchase decisions.

A quantitative approach was employed to collect data, with social media influence considered as the independent variable and market dynamics in the fashion industry as the dependent variable. Two Google forms, containing structured questionnaires in both English and Sinhala, were used to gather primary data from a diverse sample of consumers and fashion industry professionals engaged in social media for fashion-related behaviors and decisions. The study aimed for a minimum sample size of 40, including 20 consumers and 25-30 industry professionals, but ultimately received over 80 responses, with more than 50 from consumers. The collected data were analyzed using Google Forms analytics.

The study concludes that social media is a valuable market strategy for clothing businesses in Sri Lanka, facilitating business growth and significantly influencing consumer preferences. It recommends that entrepreneurs in the clothing industry harness the potential of social media to enhance their enterprises and meet the evolving demands of the market. The insights provided can guide businesses in effectively navigating the social media landscape, contributing to the industry's growth and relevance.

Keywords: Social Media, Fashion Industry, Market Dynamics, Online Marketing Strategies, Customer Engagement

Introduction

As we all know, the fashion industry has undergone a significant transition in recent years due to the use of social media platforms. This study aims to explore the complex interactions between social media platforms, particularly Facebook and Instagram, and the Sri Lankan clothing industry, with a focus on the benefits these platforms can provide to small-scale business owners. By understanding customer preferences, benefits, and the challenges faced through these social media platforms, we hope to offer valuable insights for both existing businesses and aspiring fashion entrepreneurs, ultimately contributing to the growth and sustainability of the industry in Sri Lanka.

In general, social media can be defined as a collection of online platforms that enable individuals, groups, and organizations to create, share, and interact with content and information. These platforms facilitate the exchange of various texts, images, videos, and links among users and often support features like comments, likes, shares, and messaging. Popular social media platforms include Facebook, Instagram, Twitter, LinkedIn, YouTube, Snapchat, TikTok, and many others, each catering to different types of content and audiences. Many social media platforms generate revenue through advertising and offer tools for businesses and influencers to reach their target audiences (University, 2023).

In January 2023, there were 7.20 million social media users in Sri Lanka, equivalent to 32.9 percent of the total population and 49.4 percent of Sri Lanka's total internet user base (Kemp, 2023). Jayasuriya (2022) states that the majority of youth have shifted from relying on traditional information sources such as newspapers, TV, and radio to believing Facebook as a reliable source of information. Our research focuses specifically on Facebook and Instagram social media platforms. Datareportal.com reports that there were 6.55 million Facebook users in Sri Lanka in early 2023 (Kemp, 2023). Facebook, founded by Mark Zuckerberg in 2004, allows users to create profiles, connect with friends and family, and share various forms of content. It also includes features like Messenger for private messaging, Marketplace for buying and selling goods, and a news feed that displays updates from followers and pages (Gobal, 2023). Luttrell (2018) notes that one-third of women aged 18-34 browse Facebook as their first task in the morning.


Instagram, a photo and video-sharing social media platform, was launched in 2010 and later acquired by Facebook in 2012 (Gobal, 2023). Instagram features a feed where users can see posts from accounts they follow and an Explore section for discovering new

content and users. It includes Stories for sharing temporary photos and videos, as well as IGTV for longer-form videos (Brian Holak, 2023). According to data published in Meta's advertising resources, there were 1.40 million Instagram users in Sri Lanka in early 2023 (Kemp, 2023).

Both Facebook and Instagram are widely used for social networking, communication, and content sharing, though they cater to slightly different preferences and use cases. The fashion industry is a dynamic and highly competitive sector involving the production, distribution, marketing, and consumption of fashion goods, influenced by cultural trends, economic conditions, technology, and consumer behavior (John S. Major, 2023). The clothing industry, also known as the apparel industry, is a significant contributor to Sri Lanka's economy and a key player in the global apparel market. It encompasses the design, production, and distribution of clothing and fashion-related products, involving various stages from creation to consumer sale (Embuldeniya, 2015).

Social media has enabled the rise of direct-to-consumer fashion brands. Platforms like Instagram and Facebook allow clothing brands to market their products directly to consumers, bypassing traditional retail intermediaries. This approach offers better control of branding, pricing, and customer engagement (Isuru Udayangani Hewapathirana, 2023). Clothing brands can directly engage with their customers through these platforms, receiving immediate feedback, answering questions, and building stronger relationships with their audience. Facebook and Instagram platforms have integrated shopping features, allowing users to browse and purchase products without leaving the app, thus boosting online sales for clothing brands.

Clothing brands encourage customers to create content featuring their products, such as outfit posts and reviews, which serve as



Market
strategy

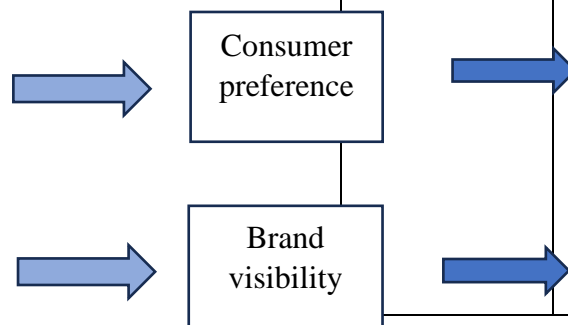
Figure 01: Conceptual Framework

In this study, we followed a quantitative research design. The questionnaires were designed to gather data based on the theories and variables discussed above.

In this study, we followed a quantitative approach to collect data, incorporating several theories to understand the variables involved. Specifically, we utilized Social Influence Theory and Consumer Behavior Theory, considering social media influence as the independent variable and market dynamics in the fashion industry as the dependent variable.

variable

Social media
influence
(Facebook and
Instagram)



Market dynamics in Fashion Industry (Clothing)

[illegible]

	<ul style="list-style-type: none"> What is your monthly household income? 	
Social Media Usage	<ul style="list-style-type: none"> Which social media platforms do you use for fashion-related content or information? How often do you use social media for fashion-related purposes? 	To explore the social media preferences and usage patterns of individuals in relation to fashion-related content.
Influence of social media	<ul style="list-style-type: none"> Have you ever purchased a fashion product after seeing it on social media? Do you follow fashion influencers or bloggers on social media platforms? How much do social media posts by fashion influencers influence your purchasing decisions? What types of fashion-related content on social media do you find most engaging? 	To investigate the impact of social media on consumer behavior in the realm of fashion.
Brand Engagement	<ul style="list-style-type: none"> Do you engage with fashion 	To explore the dynamics of consumer

	<ul style="list-style-type: none"> brands on social media through actions such as liking, commenting, or sharing their content? How important is a fashion brand's social media presence when you consider purchasing from them? Which brands do you find most influential or impactful in shaping your consumer choices and preferences? Please mention. 	engagement with fashion brands on social media platforms.
Consumer Preferences	<ul style="list-style-type: none"> What factors are most important to you when choosing fashion brands on social media? Do you prefer shopping for fashion products online or in physical stores? 	To discern the key factors influencing individuals' choices of fashion brands on social media platforms.
Overall Satisfaction	<ul style="list-style-type: none"> Please rate your overall satisfaction with the fashion products you 	Assess and quantify the level of satisfaction among consumers with

	purchased from a social media platform.	fashion products purchased through social media platforms.
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Key findings and Discussion

In our survey, we used Google Forms to collect data and received 57 responses. The form included five main parts, with the first being demographic data, which covers age, gender, education background, and income. Our research focused on consumer satisfaction regarding social media influence. We observed that the majority age group was between 18 and 24 except one who belongs to age 25-34, with most respondents being female and holding bachelor's degrees as a percentage it is 55.6% and 44.45% are male.

Social Media Usage and Influence

Analyzing the data provided insights into social media usage and its influence on consumer satisfaction. Our dataset revealed that TikTok and Instagram exert similar levels of influence on people. Many users engage with social media for fashion-related searches multiple times a day. According to the responses, 85.7% of people purchase fashion items through social media, with a majority following fashion influencers and engaging with outfit inspirations.

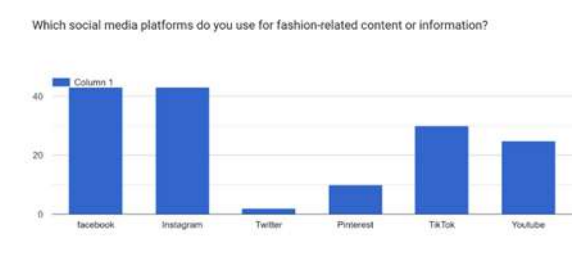


Figure 02 Social Media Usage

Brand Engagement

Social media platforms are used by brands to promote their names and items among younger audiences. We included questions to understand how this strategy impacts customers. We found that consumers engage with fashion brands on social media through likes, comments, and

shares. Additionally, most purchasing decisions are influenced by branded clothing.

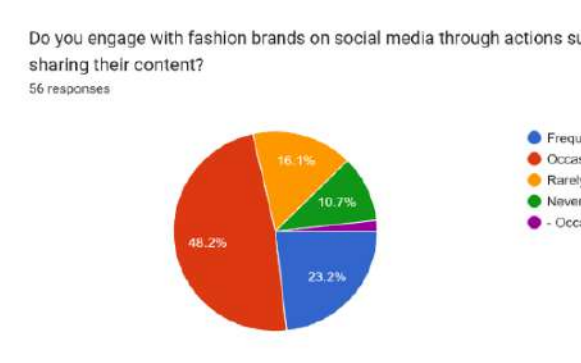


Figure 03 Brand Engagement

Consumer Preference

Our research identified key factors influencing online fashion purchases. The main considerations are product quality and price, followed by trends and style. Brand reputation also plays a role for some consumers. Despite the rise of online shopping, many people still prefer physical shopping experiences.

We received responses from 18 business pages, out of more than 40 invitations sent. Some businesses were hesitant to share their experiences due to privacy concerns. Below is an analysis of the clothing business pages' responses.

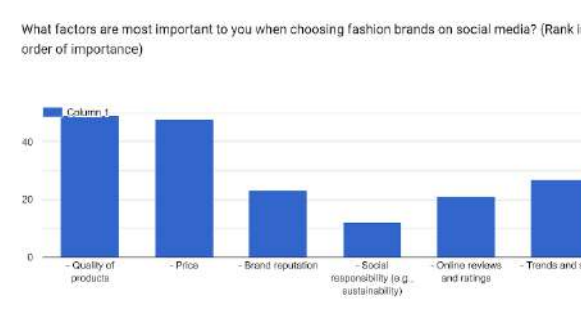


Figure 04 Consumer preference

Social Media Usage

Questions about social media usage revealed varying lengths of engagement, with most businesses using Instagram (94.4%) and Facebook (83.33%), followed by TikTok (44.4%). Other platforms like YouTube, Pinterest, and Twitter were less frequently used.

Which social media platforms do you use for your fashion business?

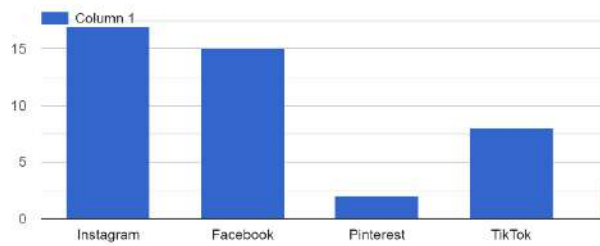


Figure 05 Social Media Usage

Posting Frequency and Purpose

Of those surveyed, 22% regularly post on social media, 61% share multiple times a week, and 16% post weekly. Most fashion firms use social media for product promotion (66.7%), brand growth (61.1%), and consumer engagement (61.1%).

Social Media Performance

Many respondents highlighted the challenge of keeping up with algorithm changes but recognized social media's potential to expand their audience and enhance brand recognition. The majority measure the effectiveness of social media marketing through sales and engagement data (83.3%).

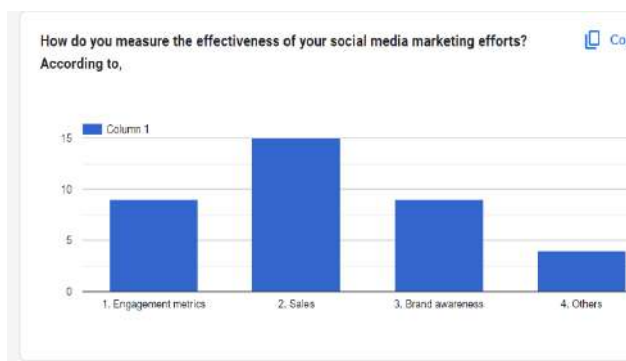


Figure 06 Social Media Performance

Customer Feedback

To collect customer feedback, 88.9% track keywords and hashtags, while others use response and engagement metrics, competitor analysis, social media analytics, and user-generated content.

Competitive Analysis

Businesses monitor competitors' social media activity through various methods, including ad expenditure insights, pricing adjustments, and content inspiration. Staying updated on social media trends is crucial, with businesses using trade journals, industry leaders' accounts, fashion conferences, and customer reviews.

Future Plans

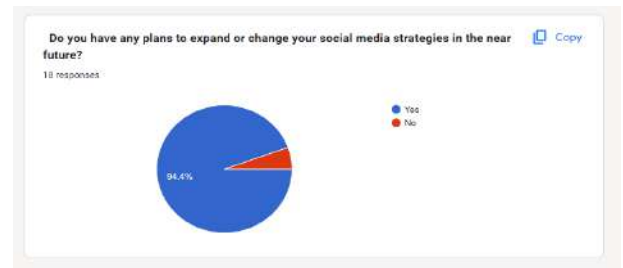


Figure 07 Future Plans

The majority (94.4%) plan to modify or expand their social media strategies in the near future, indicating a dynamic approach to social media marketing.

According to Social Influence Theory, an individual's views, beliefs, and behaviors are influenced by family, peers, and society at large. In the fashion sector, it explains how people's perceptions are shaped by what they encounter on social media. This theory suggests that individuals frequently adjust their attitudes, feelings, and behaviors in response to peer pressure and social pressure. Social networking plays a significant role in transforming Sri Lanka's fashion sector, with platforms like Facebook, Instagram, and TikTok changing how consumers view, use, and interact with fashion. By investigating Social Influence Theory, we can better understand this shift. Social media provides a platform for celebrities, fashion influencers, and regular people to share their style choices, setting trends for others to follow, making social media a powerful tool for influencing consumer behavior.

Sri Lankan fashion brands leverage social media for direct communication with consumers, receiving feedback, and understanding consumer preferences, thus influencing product development and marketing strategies. Social media's

influence has changed how Sri Lankan consumers discover, evaluate, and purchase fashion products. The younger generation is one of the most actively engaging categories on social media platforms for their clothing behaviors. Youth are not only engaging in buying goods but also tend to sell products on these platforms, possibly to earn more income. They have identified the importance of social media and the benefits of using it effectively.

In this context, we focus on Consumer Behavior Theory, which helps in understanding the purchasing patterns of consumers. Here are different types of purchase behaviors relevant to this study:

- **Routine Response Behavior:** Investigate if Sri Lankan consumers regularly buy clothing items online after seeing social media advertisements, indicating the effectiveness of recurrent social media marketing techniques.
- **Limited Decision-Making:** Explore the circumstances and reasons behind Sri Lankan consumers' restricted decision-making when purchasing clothing through social media and the factors influencing their decisions.
- **Extensive Decision-Making:** Examine situations where consumers make significant decisions, such as buying expensive clothing, and how social media influences these decisions.
- **Impulse Buying:** Study instances where consumers make spontaneous clothing purchases after viewing social media advertisements and what triggers this behavior.

After conducting our research, we identified that in the near future, there is a greater tendency to buy products online. Here are some advantages for both parties by using online platforms:

For Businesses:

- Use social media as a marketing strategy.
- Maintain awareness about social media usage.
- Develop their business without any limitations or mediators.

For Customers:

- Save time.
- Provide feedback and view others' opinions about particular goods.
- Help make informed decisions.
- Save money compared to physical shopping.

This study is based on the influence of social media on the fashion industry market in Sri Lanka. When conducting this study, we primarily discussed the background, noting that social media plays a significant role in our society. We focused on selected social media platforms, specifically Facebook and Instagram, in relation to the fashion industry. According to our research findings, we discussed consumer buying behavior and how social media influences their fashion choices.

The main point is that most of the youth crowd uses social media for fashion and online business related to the clothing sector. We realized that the age group of 18 to 24, mainly girls and young women, are the primary consumers. They focus on quality, price, trendy styles, and brands when making purchases. Businesses use various strategies to increase their customer base. Social media is a very good platform to improve or create one's own business without limitations.

Conclusion

Social media plays a crucial role in transforming Sri Lanka's fashion sector, especially among the youth. Platforms like Facebook and Instagram are pivotal for both businesses and consumers, influencing

buying behaviors and preferences. Given its significant impact, social media is recommended as a powerful tool for those looking to engage in the clothing business, offering numerous benefits and opportunities for growth.

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Perceptions of using AI powered language applications for self-studying English

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Abstract— Artificial intelligence (AI) and AI powered language applications have taken one of the crucial roles in self-learning a language. This research focuses on the experiences and the perceptions on using AI powered language applications for self-learning English among TESOL (Teaching English to the Speakers of Other Languages) practitioners of General Sir John Kotelawala Defence University, Sri Lanka. The rapid progress of AI made the language learning applications based on the adaptability, flexibility, accessibility and versatility of the individuals which suits each learner's pace, style and preferences. This study has used a mixed method approach including questionnaires (quantitative) and focus group discussion (qualitative). According to the convenient sampling, about 91 TESOL practitioners of General Sir John Kotelawala Defence University, Sri Lanka were considered as the sample of the study. The key findings of the study reveal that 85% of TESOL practitioners found AI-powered language applications significantly enhanced their English learning and based on the demographic variations, younger users, non-native speakers, and those with specific language needs found AI tools particularly beneficial. This study offers useful information for educators, application developers and policy makers to

improve the effectiveness of AI powered language applications and learning systems..

Keywords— Artificial Intelligence, AI powered language applications, Autonomous learning, Perceptions of TESOL Practitioners

I. INTRODUCTION

Artificial Intelligence (AI) is revolutionizing language learning by providing personalized, efficient, and interactive tools for self-study. AI-powered language applications leverage advanced algorithms to adapt to individual learning styles, offering tailored lessons and instant feedback to enhance English proficiency.

ChatGPT is an AI language model that simulates human-like conversations. It helps learners practice writing and comprehension by engaging in dialogues, answering questions, and providing explanations on various topics, thereby improving their conversational skills and grammar.

ELSA (English Language Speech Assistant) focuses on enhancing pronunciation and speaking abilities. Using speech recognition technology, it analyzes users' speech patterns and provides real-time feedback on pronunciation, intonation, and fluency, helping learners speak English more confidently and accurately.

Duolingo offers a gamified learning experience covering reading, writing, listening, and speaking skills. Its AI adapts to the user's performance, adjusting the difficulty of exercises to optimize learning. The app's interactive lessons and quizzes make learning engaging and effective.

Lingopie helps to improve listening and comprehension skills through watching TV shows and movies in English with interactive subtitles. Users can click on words and phrases for instant translations and explanations, enhancing vocabulary and understanding of context in an enjoyable way.

These AI-powered apps make self-learning English more accessible by providing customized experiences that cater to individual needs. They enable learners to study at their own pace, focus on specific areas for improvement, and receive immediate feedback, all of which contribute to a more effective and engaging learning process.

This study presents a detailed examination of the experiences and perceptions of TESOL (Teaching English to Speakers of Other Languages) practitioners at General Sir John Kotelawala Defence University, Sri Lanka, regarding the use of AI-powered language applications for self-studying English.

II. LITERATURE REVIEW

The influence of AI-powered language applications for self-studying English has been investigated by many scholars due to the contemporary existence of artificial intelligence as a resource for self-language learning.

As supported by existing literature, Ling Wei et.al (2023) has conducted research on artificial intelligence in language instruction, its impact on English learning

achievements, L2 motivation, and self-regulated learning in English as a foreign language learner.

Two classes with sixty-nine university students have taken part in this study. The experiment group received AI-oriented language instructions, while the control group received traditional instructions. The pre- and post-tests were administered to ascertain the English language learning achievements of both groups. Thereafter, a questionnaire was given to assess learners' perceptions of AI-oriented L2 learning. Thus, the analysis of qualitative data demonstrated that the experiment group gained a higher number of outcomes in all the assessed areas like grammar, vocabulary, writing, speaking, etc. The thematic analysis of the qualitative questionnaire resulted in students being highly engaged and motivated for AI-oriented language learning.

Hence Sherry Ruan, Liwei Jing, Qian Yao Xu, Zhiyuan Liu, Glenn M. Davis, Emma Brunskill, and James A. Landay (2021) developed an artificial intelligence (AI)-oriented English bot, a language learning chatbot that discusses college-related topics and provides immediate feedback.

The research group has evaluated the influence of an artificial intelligence-mediated chat bot against traditional instructions and repeated interfaces with 56 Chinese college students. This study found that the AI chatbot has positively influenced students' perceptions of language instructions, increasing their motivation, interactivity, and engagement.

Moreover, Belle Li, Curtis J. Bonk, Chaoran Wang, and Xiaojing Kou (2017) conducted an interview among nineteen YouTubers to examine the YouTube content creators' language learning experience and the role of ChatGPT in their self-directed language learning (SDLL) based on Song and Hill's conceptual model of SDLL in an online platform.

This study underlines the effectiveness of ChatGPT as a tool for increasing self-directed language learning (SLDD). Thematic analysis has been employed for the qualitative data analysis phase.

A. Research Gap

While previous studies, such as those by Ling Wei et al. (2023) and Ruan et al. (2021), have demonstrated positive impacts of AI-powered language applications on language achievement, motivation, and engagement, there remains a gap in understanding learners' specific perceptions regarding these tools, particularly in self-directed learning environments. The focus has largely been on traditional classroom settings or structured experiments, with limited attention given to autonomous learners using AI

applications outside formal educational settings. Additionally, the role of AI applications in fostering long-term language learning habits and their effectiveness in different demographic groups has not been fully explored.

This study aims to fill this gap by investigating the perceptions of individuals using AI-powered language applications specifically for self-study purposes, examining how these tools support their language learning progress, motivation, and self-regulation.

B. Research Questions

- i. How do TESOL practitioners at General Sir John Kotelawala Defence University perceive the use of AI-powered language applications for self-learning English?
- ii. What are the specific experiences of TESOL practitioners when using AI-powered language applications for self-learning English?
- iii. What are the most popular AI-powered language applications used by TESOL practitioners at General Sir John Kotelawala Defence University, and why?

III. METHODOLOGY

A mixed-method approach was used for this study, which include quantitative questionnaire and qualitative focus group interview. The questionnaire made by google form was provided to collect information about perceptions of 91 TESOL practitioners on Impact of AI powered language apps for self-studying English, while focus group interview provided in-depth sights. Moreover, questionnaire was completed with 15 questions including both open and closed and got 91 results from intake 39,40 and 41 TESOL undergraduates, respectively. From each intake, 2 TESOL undergraduates participated in the focus group interview in order to have in-depth views on AI powered language apps for self-studying English.

The focus group interviews were semi-structured, allowing participants to elaborate on their experiences with AI-powered language applications. Open-ended questions were designed to probe deeper into topics such as their motivation for using these tools, perceived benefits and challenges, and their impact on language proficiency. Each focus group interview lasted approximately 45 minutes and was audio-recorded with participants' consent.

The qualitative data from the focus group interviews were transcribed and the transcripts were read and re-read to become familiar with the content. After that, as they mentioned different opinions, the key ideas were grouped based on some themes matching with the research gaps and research questions. This is almost like a thematic analysis but this contains as the summary of the insights.

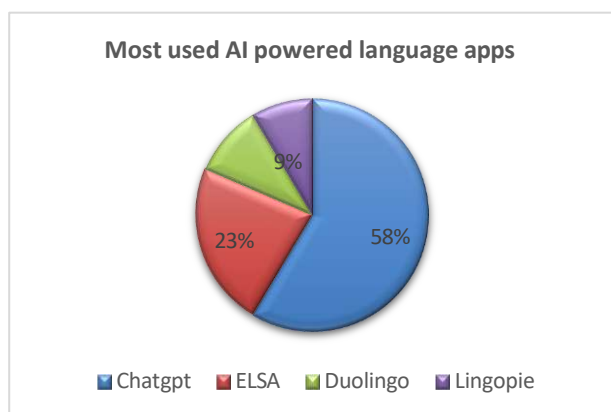


Figure 1. Most used AI powered language Apps

By combining both quantitative and qualitative methods, the study provides a better understanding of Impact of AI powered language apps for self-studying English, providing deep and valuable insights for both linguistic and AI technology fields.

IV. RESULTS

A. Quantitative Results

Majority (approximately 85%) of the 91 TESOL practitioners reported that AI-powered language applications enhanced their English learning experience. Descriptive statistics showed high satisfaction rates regarding the adaptability, flexibility, and accessibility of these applications. Moreover, participants noted considerable improvement in various language skills, such as,

- Grammar and Vocabulary: 80% of participants reported noticeable enhancements.
- Speaking and Writing: Around 75% indicated significant progress.
- Listening and Reading Comprehension: 70% observed substantial improvements.

According to the results, 65% of participants regularly incorporated AI-powered language applications into their academic routines, utilizing them for lesson planning, student engagement, and personal language development. Also, the survey identified that ChatGPT is used by 58% of the participants, while ELSA is used by 23% of participants, Duolingo is used by 10% of participants and Lingopie is used by 9% of the participants (Figure 1).

B. Qualitative Results

Focus group discussions revealed that participants valued the personalized learning paths offered by AI applications, which allowed them to focus on their weak areas and progress at their own pace.

Many practitioners (around 80%) expressed increased engagement and motivation when using AI-powered tools, attributing this to the interactive and responsive nature of the applications.

Also, they highlighted that AI applications not only improved their own language skills but also provided innovative methods to engage students. Approximately 70% of participants used AI tools to create more interactive and effective lesson plans.

There are some differences identified based on the age, mother tongue, requirements and mental health of the participants.

- Age:** Participants who are younger than 21 years old were more enthusiastic and quicker to adapt to AI tools compared to others.
- Mother Tongue:** Participants whose mother tongue was not English (Sinhala and Tamil) found AI applications particularly beneficial in bridging language gaps.
- Requirements:** Practitioners with specific language needs (e.g., academic writing, speaking) appreciated the tailored content provided by AI applications.
- Mental Health:** Participants experiencing stress or anxiety found the adaptable and flexible nature of AI applications supportive, allowing them to learn in a less pressured environment.

v. DISCUSSION

This study has investigated whether AI-powered self-learning applications have positively impacted TESOL practitioners. The undergraduates perceived a tailored learning experience that addressed their individual learning experiences. Furthermore, the utility of language learning applications has enhanced their language learning and supported their teaching practices as well. Learner differences such as age, mother tongue, requirements, and mental health elucidate the dire need for designing tailored approaches for language learning in order to access each kind of learner difference. This study provides insights to policymakers, application developers, and educators on how to harness AI applications to enhance individuals' language learning experiences in an optimistic way. AI-powered language applications provide tailored, efficient, engaging, and versatile language learning experiences for individuals, fostering their desire to learn languages.

v. CONCLUSION

This study clarifies the essential role of AI-powered language applications in the self-study of English among TESOL practitioners at General Sir John Kotelawala Defense University, Sri Lanka. The study confirms that these applications offer personalized and adaptive learning experiences which cater to the diverse needs and

preferences of individual learners. The study effectively captures both the quantitative impact and qualitative insight of using AI in language learning by employing a mixed method approach.

The findings highlight the significant positive perceptions among TESOL practitioners regarding the effectiveness of AI powered tools in enhancing their English proficiency as well as their teaching methodologies. Especially, the study reveals that learner differences such as age, mother tongue, specific requirements, and mental health significantly influence their perceptions and experiences with these applications. This underscores the importance of designing AI language learning tools which are adaptable and sensitive to these diverse needs.

For educators, application developers, and policy makers, this research offers valuable guidance on optimizing AI language applications to support and enhance language learning outcomes. By manipulating the adaptability and personalized nature of AI, stakeholders can create more effective and engaging learning environment that cater to the unique needs of every learner.

In conclusion, the integration of AI powered language applications in self learning represents a promising advancement in educational technology, fostering more efficient, engaging, and tailored learning experiences. This study not only contributes to the understanding of the impact of AI on language learning but also sets the stage for future innovations and improvements in this dynamic field.

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An Investigation into Language Assessment Literacy among ELT Professionals in Sri Lanka

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Abstract- Assessment Literacy is a major component which a language teacher should have gained, as it affects to the quality of teaching and learning. This research is an investigation on Language Assessment Literacy of English Language Teaching professionals in Sri Lanka. The research question of current study investigated whether to what extent do the English language Teaching professionals in Sri Lanka have Language Assessment Literacy. This study has applied quantitative research methodology and a questionnaire was used to collect data from the stakeholders. The knowledge and the skills that were related to assessment literacy were assessed using the questionnaire and it included 71 Language Assessment Literacy aspects. The 71 statements were in a Linkert scale and participants had to rate 0-4 by following the given explanations that were based on their knowledge. 53 ELT professionals from different districts and provinces in Sri Lanka participated in this research. The findings of this research indicated that, ELT professionals were moderately knowledgeable and their knowledge varied from one another as there were different ELT professionals such as language teachers, language testing/assessment developers, test score users and professional examiners and raters. This study contributes for the development of ELT professionals' knowledge and skills by providing a self-assessment to identify the areas they lack under Language Assessment Literacy aspects and revealing their level of the knowledge on assessment literacy. The

questionnaire of this research will also help English Language Teaching professionals to have a self-evaluation upon themselves to have an idea about the areas that they should improve on assessment literacy. The results of this study can be used in syllabus designing of pre-service English Teaching courses and for in-service continuous professional development programs.

Keywords- Language Assessment Literacy, English Language Teaching professionals, LAL

I. INTRODUCTION

Assessment is important component in education (Serpil & Derin, 2017). Coombe et al., (2007) as cited in Serpil & Derin, (2017) stated that assessment can be interpreted in numerous ways of gathering data based on the learner's language potential or achievement. In classrooms, teachers will have to play distinct roles according to the situation such as sometimes teachers will have to act the role of an assessor and then again he/she will have to play the role of a consumer as well. Classroom assessments provide the opportunity to get feedback on the effectiveness in teaching and learning.

Language Assessment Literacy demonstrates the stakeholders' acknowledgement of knowledge, skills, and principles in Language Assessment (Fulcher, 2012; Giraldo, 2018 as cited in Cui et al., 2022) and how the educators implement these components in their practical teaching process. Under the topic of Investigation on Language Assessment Literacy (LAL) among ELT professionals in Sri Lanka, this research focused on certain LAL aspects based on knowledge and skills that should be there within ELT professionals such as English language teachers, English lecturers, professional examiners, language assessment/ test developers, and test score users. Scholars state that in-service English language teachers should have gained LAL and pre-service English Language Teaching programs should have been encouraged to provide quality knowledge based on LAL to improve the quality of teaching and learning (Popham, 2009; Schafer, 1993 as cited in Giraldo, 2018). Language Assessment Literacy (LAL) directs teachers to make better decisions about the development, administration, and benefits of using assessment (Harding & Kremmel, 2016; Popham, 2009 as cited in Stabler-Havener, 2018).

An educator who has a better knowledge of LAL, has the ability to design better open-ended and closed-ended tasks, grant clear and proper rubrics for productive skills such as speaking and writing, and can use assessment feedback in learning and teaching process (Fulcher, 2012 as cited in Giraldo, 2018). Furthermore, researchers all over the world have identified teachers' Language Assessment Literacy is quite low (Popham, 2009). Therefore, it is important to investigate Language Assessment Literacy among English Language Teaching (ELT) professionals in Sri Lanka as assessments play a major role in students' lives. For example, high-stakes assessments. Since only two studies have been conducted in Sri Lanka (Munasinghe, 2020; De Silva, 2021) and those studies focus on different areas of Language Assessment Literacy, there was a need of investigating Language Assessment Literacy among English

Language Professionals in Sri Lanka . This research can lead to improvements in various factors in English language teaching such as teaching strategies, curriculum design, and overall quality of language education.

RQ- To what extent do ELT professionals in Sri Lanka have language assessment literacy?

Isn't there a literature review? Or is it included in some other section? If so, where?

II. Methodology

This investigation focused on Assessment Literacy of ELT professionals from various districts in Sri Lanka. Therefore, it was an open questionnaire as it gave the opportunity to respond for all English Language Teaching professionals in Sri Lanka. The questionnaire included 71 statements. Later those statements were divided into 10 hypothetical dimensions as below (Harding & Kremmel, 2019).

Table 1: Hypothesized items and related statement numbers

Hypothesized dimensions	Statement numbers (see Appendix 1)
Knowledge of the theory	26, 27, 28, 33, 41, 42
Principles and concepts	31, 32, 40, 43, 44
Language pedagogy	1, 2, 3, 4, 5, 6, 7, 8, 17, 19, 21, 23, 24, 25
Impact and social values	18, 22, 29, 34, 35, 36, 37
Local practices	11, 12, 13, 14, 38, 39
Personal beliefs/ attitudes	45, 46, 47, 48
Scores and decision-making	9, 10, 15, 16, 20, 30
Technical skills (A) – Constructing language assessments	54, 57, 58, 59, 60, 62, 63, 68, 69, 70, 71

Technical skills (B) – Administrating/ scoring language assessments	53, 55, 56, 61, 67
Technical skills (C) – Evaluating language assessments	49, 50, 51, 52, 64, 65, 66

Responses were collected from the districts such as Colombo, Gampaha, Kurunegala, Puttalam, Hambanthota, Polonnaruwa, Kandy, Nuwara Eliya, Kegalle, Trincomalee, Ampara, Matale, Galle, and Matara.

Data were gathered from 53 English Language teaching professionals. Both female and male participants contributed to this investigation, and some has chosen not to reveal their gender identity. 67% percent of participants represent females, 25% of participants represent males and 8% of participants prefer not to tell their gender identity. Language teachers, teacher trainers, teacher advisors, professional examiners or raters, university lecturers, assistant lecturers, teacher educators, language assessment developers, and test score users have participated in this research. When considering about the years of experience, there were ELT professionals starting from 1 year experience to 33 years of experience. Also, 7% of the ELT professionals selected 'novice', 70% of the participants chose 'competent' and 22% of the participants selected 'expert' where the participants had to self-evaluate their current professional role according to their self-reflection. There was from pre-intermediate level to advanced level ELT professionals according to their self-evaluation on their language proficiency. 15% of the participants were at the intermediate level, 11% were at the pre-intermediate level, 48% of participants were at the upper intermediate level and 26% of the participants were at the advanced level accordingly to their self-evaluations on the language proficiency level.

III. Research design

As the data collection instrument, a questionnaire was used. Several existing LAL survey questionnaires was mentioned in the literature review. The questionnaire was adopted from Harding & Kremmel (2019). Almost 83 questions are there in the questionnaire. There were ten sections in this questionnaire. This was piloted and used in UK Harding & Kremmel (2020). Therefore, several changes were made to make it suitable for the current study.

In the first section, participants had to read the consent form and select whether they like to participate in this research voluntarily or not. Second section included background details of the participants such as selecting the identities that are relevant to them. They had to select from a list of identities and that list included, language teacher, professional examiner and/or rater, language assessment/ test developer (a professional who creates tests or assessments, writes questions, develops scoring guides, etc.), language assessment/ testing researcher, policy maker, test score user and test taker. The reason to add this question was there can be professionals who has multiple identities such as there can be language teachers who are engaged in test developing as well. Next they had to include the level of the learners that they were teaching. They had to state whether their learners are at, primary level, secondary level, higher education or adult education. In the third section, the participants had to choose a one profession among the previously mentioned professionals, and it was supposed to be the profession that they will be focusing on answering the other questions that are there in the questionnaire. After that, they had to select the level of experience on their current professional role. As the next question, participants had to self-evaluate their language proficiency level. From the 4th section, they had to state whether how far the people among the chosen profession had the knowledge on the given statements that

are related to language assessment. Also, they had to rate their opinions accordingly to the given rating scale. If they are not knowledgeable at all, they should select option 0. If the participants are slightly knowledgeable, they should select the option 1. If the participants are moderately knowledgeable, they should select the option 2. The participants should select the option 3, if they are very knowledgeable. When the participants are extremely knowledgeable about the relevant statement, they had to select the option 4. In the questionnaire, the rating scale is mentioned within each ten statements to make the rating easier for the participants. The questionnaire included 71 statements to focus on measuring the knowledge and skills based on LAL aspects. To respond these statements five-point rating scale were made as before. So that, the participants had to select the suitable option according to their perspectives. Once they are done with the linkert scale, participants had to rate their level of confidence in answering the previous questions. In the later part of the questionnaire, they had to include some biodata such as gender, age, years of experience in current position, the district that they were currently working. Finally, a space was provided to add their comments regarding the survey.

IV. Results

In analysing the data, an Excel spread sheet was used. As the questionnaire was created from Microsoft Forms, it was easier to open the data in an Excel spread sheet. After that, the data of one participant had been removed because, he/she had not agreed to volunteer in this research though he/she had answered all questions that was there in the questionnaire. As the rating scale starts from 0-4 and '0' has no value, the data had been replaced as, the places that had option 0 as 1, option 1 as 2, option 2 as 3, option 3 as 4, and option 4 as 5. Therefore, number one symbolizes not knowledgeable/skilled at all. Number 2 stands for slightly knowledgeable or skilled. Number 3 demonstrates the data

that meant moderately knowledgeable/skilled. The data which meant very knowledgeable/skilled were shown by number 4. Extremely knowledgeable data were represented by number 5. Thereafter, the Mean score was calculated for each statement using Excel formula (For example- =AVERAGE([1] How to use assessments to guide learning or teaching goals])). Then the step was to find the standard deviation of all 71 statements and the relevant formula was used to calculate(For example, =STDEV.S(Table1[1] How to use assessments to guide learning or teaching goals])). After that, the 71 statements had been divided according to 10 hypothesized dimensions as demonstrated in table 1 (Harding & Kremmel 2020).

Table 2- Total Mean Scores of the hypothesis

Hypothesized dimensions	Total mean score of the hypothesis
Knowledge of the theory	3.14
Principles and concepts	2.97
Language pedagogy	3.34
Impact and social values	3.03
Local practices	2.95
idPersonal beliefs/ attitudes	3.12
Scores and decision-making	3.29
Technical skills (A) – Constructing language assessments	3.01
Technical skills (B) – Administrating/ scoring language assessments	3.05
Technical skills (C) – Evaluating language assessments	3.02

Stakeholders was moderately knowledgeable on the knowledge of the theory hypothesis as the total mean score of the hypothesis was 3.1. ELT professionals had a knowledge that is closer to moderately knowledge rate based on principles and concepts because the total mean was 2.9. Third hypothesis was on language pedagogy and stakeholders were moderately knowledgeable because the total mean for the hypothesis was 3.3. ELT professionals were moderately knowledgeable on impact and social values as well cause the overall mean score for the hypothesis was 3.0. Stakeholders were closer to moderately knowledgeable rate on local practices and the total mean score for this hypothesized dimension was 2.9. Participants were moderately knowledgeable on personal beliefs and attitudes and the total mean for the hypothesis was 3.1. When considering about scores and decision-making, stakeholders had a moderate knowledge too as the total mean score was 3.2 of the hypothesized dimension. Also, the total mean score of the 3 technical skills that demonstrated the final 3 hypothesis was 3.0 for each hypothesis and stated that stakeholders were moderately knowledgeable on constructing language assessments, administering/ scoring language assessments, and evaluating language assessments.

V. Discussion

The main findings of this study revealed that ELT professionals in Sri Lanka were moderately knowledgeable on LAL. When considering the standard deviations of the findings which were tested the LAL aspects of the participants', the data were spread from the average score which means that the stakeholders' knowledge varied from one another. Gardener & Rea-Dickins, (2001) as cited in Vogt and Tsagari, (2014) denoted that teachers' LAL is at under developing stage too. According to the findings of Kremmel & Harding, (2020) stated that LTA developers and researchers need a high level of expertise developing and evaluating language assessments and also a deep knowledge about LAL principles. Taylor, (2013) also stated that levels of the different stakeholders vary in their knowledge of LAL.

Not only that, Malone, (2013) indicated that ELT professionals have different perspectives.

VI. Conclusion

RQ- To what extent do ELT professionals in Sri Lanka have language assessment literacy?

LAL is an essential component in teaching as discussed in the literature review and Crusan, Plakans, and Gebril 2016, as cited in Valizadeh, (2019) stated that LAL can influence for teachers' ideologies as well. The following table represents the total mean of the 10 hypothesized dimensions.

The current study investigated the LAL among ELT professionals in Sri Lanka. Stakeholders had a moderate knowledge of LAL and their knowledge varied from one another. These findings can be used in syllabus designing for pre-service and in-service courses/CPD (Continuous Professional Development) programs as it will help to design language assessment content by giving a better idea about the LAL aspects which should be focused more. Also, this study will help to identify the LAL strengths and weaknesses of ELT professionals in Sri Lanka and the stakeholders will be able to develop their needs after recognizing those as they granted a self-evaluation on LAL in participating in the questionnaire. As for the limitations of this study, it was quite difficult to generalize the findings of this research as there were 53 participants to represent ELT professionals, and also, some participants were excluded as they did not intend to volunteer as participants though they had answered the questionnaire. It was quite difficult to find volunteers as the questionnaire was too long and people don't like to participate in completing long questionnaires. Based on these findings, researchers can investigate the reasons that have led them to have a moderate knowledge of LAL, authorities can research the possible ways of enhancing the LAL among these professionals.

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ID 445

Clustering Analysis of Performance Differences Between Veteran and Rookie Basketball Players.

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Abstract –Professional basketball teams constantly strive to balance veteran leadership with emerging talent, aiming to optimize player performance and team success. This study aims to analyze the impact of experience on player performance by comparing veterans and rookies using their statistics over five years. The study focuses on key performance metrics, including points, player efficiency rating (PER), win shares (WS), box plus/minus (BPM), and value over replacement players (VORP). Players with less than four seasons were classified as 'Rookies,' while those with four or more seasons were classified as 'Veterans.' Using K-means clustering we identified three distinct clusters based on performance metrics. Cluster 0 had rookies with low values of performance metrics, Cluster 1 included both rookies and veterans having medium values, and Cluster 2 consisted only of veterans with high values. To validate and support our findings DBSCAN recognized high-performing veterans as outliers. Our findings illustrate the significance of experience in player performance as

veterans consistently outperformed rookies in all metrics. The study suggests improving team performance by combining rookies with veteran expertise. It is possible that future research would then go on to develop an even deeper understanding of performance dynamics using new algorithms or measurement techniques.

Keywords: Basketball, Sports analytics, K-mean clustering, DBSCAN, Clustering Analysis

I. INTRODUCTION

Teams in professional basketball seek to strike a balance between veteran leadership and emerging talent. The paper argues whether experience impacts player performance by contrasting the performances

of veterans and rookie performances. In this respect, performances are analyzed based on a five-year dataset, focusing on popular performance indicators such as points, PER, WS, BPM, and VORP. High-level clustering methods can assess latent patterns and trends distinguishing rookie from veteran performances. It aims to directly inform coaches, analysts, and the decisions of team managers in player development and team composition.

Evaluating the performance differences between veteran and rookie players in professional basketball is crucial for understanding how experience influences player effectiveness and contributes to team success. Veterans, with their extensive experience, often bring consistency, strategic insight, and leadership to the court, while rookies, who are relatively new to professional play, exhibit high potential but face the challenge of adapting to the demands of the game (Lorenzo, et al., 2019)

Veteran players are frequently noted for their reliability and ability to perform under pressure, which significantly impacts team performance and strategy. Conversely, rookies may show promising talent but struggle with the transition to a professional level, making it essential to understand how these differences manifest in performance metrics. This comparison helps assess how experience translates into performance and informs decisions related to player development and team composition (Lorenzo, et al., 2019).

The selection of appropriate metrics that evaluate the performance of players holds a strategic position in measuring a player's contribution to the team's successes. Points (PTS), Player Efficiency Rating (PER), Win Shares (WS), Box Plus/Minus (BPM), and Value Over Replacement Player (VORP) were chosen for analysis because they present a comprehensive estimate of the performance. Points focus on the ability of a player's scoring ability as it directly informs of the amount that a player contributes to an offense. Player Efficiency Rating combines many statistical achievements into one while showing how efficiently a player performs on the field. Win Shares predict the overall wins a certain player delivers to the specific team they belong to, by combining both offense and defense aspects. This metric is useful for connecting individual performance to team achievements, and success but may not accurately reflect players with limited roles or those on less successful teams. Box Plus/Minus calculates a player's performance per 100 possessions while adjusted for team context. Value Over Replacement Player assesses a player's value compared to a hypothetical replacement player, reflecting their overall contribution. Metrics such as FG%, 3P%, and AST were excluded from this study

due to their narrower focus on specific aspects of performance, which may not fully capture the holistic contributions of players.

To analyze performance differences, K-means clustering and DBSCAN were selected for their ability to segment and identify patterns within the data. The k-means clustering method was chosen for its effectiveness in partitioning players into distinct clusters based on performance metrics. With ($k=3$), players are categorized into low, medium, and high-performance groups, which helps in understanding different performance levels among veterans and rookies. The DBSCAN algorithm was used to detect outliers and clusters of varying shapes and densities, particularly identifying high-performing veterans who may not fit into the general clusters identified by K-means. DBSCAN's strength lies in its ability to find outliers and handle noise, making it suitable for identifying exceptional cases.

While existing research extensively utilizes advanced metrics for player evaluation, there is a gap in studies specifically comparing veteran and rookie players using a comprehensive set of metrics and advanced clustering techniques. This study fills this gap by providing a detailed comparison of how experience impacts key performance indicators and integrates K-means and DBSCAN clustering to offer nuanced insights into performance differences.

By focusing on career stage differences and their impact on performance metrics, this research contributes to a deeper understanding of player evaluation, providing valuable insights for team management and player development strategies. This study's findings can inform decisions related to team composition, player development, and strategic planning in professional basketball.

II. METHODOLOGY AND EXPERIMENTAL DESIGN

A. Data Collection

The dataset was sourced from the official NBA website, ensuring accurate and up-to-date statistics for the 2019-2024 season. Five years was chosen to balance between capturing current trends and maintaining statistical robustness, ensuring meaningful analysis without excessive historical bias.

B. Data Preprocessing

Initially, rows where the 'Tm' column value was 'TOT' were removed from the dataset. This filtering step was critical to exclude aggregated statistics that combined performances from multiple teams, which could skew the analysis. After removing these rows,

which contained aggregated data, null values in the remaining dataset were addressed.

Selected Metrics and Their Relevance

1. Player Efficiency Rating (PER):

PER is a per-minute rating developed by John Hollinger that summarizes a player's statistical accomplishments in a single number. It accounts for various aspects of performance including scoring, assists, rebounds, steals, and blocks, while also considering the negative impacts of turnovers and missed shots. PER is chosen because it provides a comprehensive measure of a player's overall efficiency and effectiveness on the court. It condenses multiple performance aspects into a single metric, making it easier to compare players across different roles and positions. By including PER, the analysis captures the general impact and efficiency of players, crucial for understanding their contributions to the clustering process.

2. Win Shares (WS):

Win Shares is a metric that estimates the number of wins a player contributes to their team. It is divided into offensive and defensive components and aggregates them to provide a single value. WS is selected because it provides a direct link between player performance and team success. This metric helps in assessing how well a player's contributions translate into actual wins, which is essential for evaluating the effectiveness of both veterans and rookies. Including WS ensures that the clustering analysis considers how players' contributions affect their team's overall performance.

3. Box Plus/Minus (BPM):

BPM is an advanced statistic that estimates a player's impact on their team's performance per 100 possessions, combining both offensive and defensive contributions. It includes components for offensive BPM and defensive BPM. BPM is included because it provides insight into a player's impact on both ends of the court, normalized for team pace. It helps in understanding how effectively a player contributes to their team's performance beyond just scoring or traditional stats. By incorporating BPM, the analysis accounts for players' overall influence on game outcomes, adding depth to the performance evaluation.

4. Value Over Replacement Player (VORP):

VORP estimates a player's contribution relative to a replacement-level player, providing a measure of how much better a player is compared to a baseline level

of performance. VORP is chosen because it quantifies a player's value in terms of their impact relative to an average or replacement-level player. This metric is crucial for understanding how much more valuable a player is compared to readily available alternatives. It helps in distinguishing high-impact players from those who provide less significant contributions, which is vital for clustering and comparing veteran and rookie players.

The research question focuses on clustering players to compare the performance profiles of veterans and rookies. The selected metrics are integral because PER, WS, BPM, and VORP together cover multiple facets of player performance, including efficiency, team impact, and overall contribution. This ensures a well-rounded evaluation of players' abilities and achievements. These metrics allow for differentiation between veterans and rookies based on their statistical profiles and impact on the game. They help in identifying performance trends and patterns that are crucial for understanding the differences between experienced and new players. Metrics like WS and BPM connect individual performance to team success and overall game impact, making them essential for assessing how players' contributions affect their teams' outcomes. Including these metrics ensures that the analysis captures a broad and nuanced view of player performance, facilitating an effective comparison between veteran and rookie players.

An additional feature, `Seasons_Played`, was computed to categorize players into rookies and veterans. This classification enables the analysis of performance differences between experienced players and newcomers where players are labeled as 'Rookie' if they have played fewer than 4 seasons, and 'Veteran' if they have played 4 or more seasons.

The metrics were standardized using `StandardScaler` to ensure that all features contributed equally to the clustering process. Standardization removes scale bias and normalizes the data, facilitating a fair comparison across different performance metrics.

C. Clustering Analysis

K-Means was selected for its efficiency in partitioning data into distinct clusters based on feature similarity. It is well-suited for identifying well-separated groups in the dataset, which is crucial for distinguishing performance levels among players. The number of clusters was determined using the Elbow Method, which helps in identifying the optimal number of clusters by evaluating the within-cluster sum of squares (WCSS).

DBSCAN (Density-Based Spatial Clustering of Applications with Noise) was chosen for its ability to identify clusters of varying shapes and handle noise

in the data. It is effective for detecting outliers and clusters with non-spherical shapes, which complements the K-Means approach. Parameters such as epsilon (ϵ) and minimum samples were tuned to capture clusters and noise effectively, providing a more comprehensive analysis of player performance.

D. Experimental Design

a. Evaluation Metrics

Silhouette Score was used to assess the quality of the clusters. It measures how similar a data point is to its cluster compared to other clusters.

b. Bias Mitigation

The dataset contains 420 veteran players and 360 rookie players, ensuring a balanced representation of both groups. This helps in minimizing potential biases related to player experience.

E. Methodology

a. Clustering Approach

We applied the DBSCAN (Density-Based Spatial Clustering of Applications with Noise) clustering algorithm to categorize players based on their performance metrics. DBSCAN is a popular clustering technique for identifying clusters of varying shapes and sizes while handling noise effectively.

b. Parameter Selection

The choice of DBSCAN parameters, specifically ϵ (the maximum distance between two samples for them to be considered as in the same neighborhood) and $\min_samples$ (the minimum number of samples in a neighborhood for a point to be considered as a core point), was determined through extensive testing. We evaluated various values for these parameters to find the optimal balance between detecting meaningful clusters and minimizing noise. The selected parameters provided the best trade-off, resulting in a silhouette score of 0.507, which indicated a reasonable separation between clusters and a manageable level of noise.

III. RESULTS

The dataset included a total of 780 players consist of 420 veterans and 360 rookies. To answer the question about these two groups' performance, we summarized the key performance metrics: Points, Player Efficiency Rating, Win Shares, Box Plus/Minus, and Value Over Replacement Player. The table below shows a summary of these metrics for both rookies and veterans:

Player_Type	PTS	PER	WS	BPM	VORP
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Rookie	8.4	12.7	1.5	-1.5	0.2
Veteran	15.6	18.2	5.4	2.3	2.1

Table 1. Summary of metrics for both rookies and veterans

The general trend seen in these figures is that veterans outperformed rookies, indicating a general increase in performance with experience.

J. K-Means Clustering Results

We employed the K-means clustering algorithm to segment players into distinct performance groups using key metrics such as Points (PTS), Player Efficiency Rating (PER), Win Shares (WS), Box Plus/Minus (BPM), and Value Over Replacement Player (VORP). These metrics were chosen due to their comprehensive reflection of both individual scoring ability and overall team contributions. To determine the optimal number of clusters, we utilized the Elbow Method, which indicated that three clusters provided the best balance between simplicity and accuracy.

The K-means algorithm identified three clusters, categorizing players into low, moderate, and high performers. These clusters offer a holistic evaluation of each player's impact on the game, considering both offensive and defensive contributions. The mean values for each performance metric across the clusters are presented in Table 1.

Cluster	PTS	PER	WS	BPM	VORP
0	38.34	14.84	8.89	-0.31	1.84
1	10.68	9.52	1.14	-4.17	-0.22
2	86.68	21.90	24.61	4.43	10.86

Table 1: Summary of K-means Clustering Results

Based on these metrics, the clusters were categorized as follows:

Cluster 0: Moderate Performers – This group, primarily composed of rookies, demonstrated average performance across all metrics. Although showing potential, players in this cluster exhibit room for improvement, especially in critical areas such as Win Shares and PER.

Cluster 1: Low Performers – Consisting mainly of rookies, this cluster recorded significantly lower scores across all metrics. These players had the lowest average performance, particularly in metrics such as BPM and VORP, indicating limited contributions to their respective teams.

Cluster 2: High Performers – Exclusively comprised of veterans, this group displayed superior

performance in all key metrics, particularly in Points and Player Efficiency Rating. The significantly higher values across all metrics highlight these players' critical roles in their teams' successes.

These clusters reveal a strong correlation between player experience and performance, with veterans consistently occupying the high-performing cluster, while rookies predominantly populate the moderate or low-performing groups.

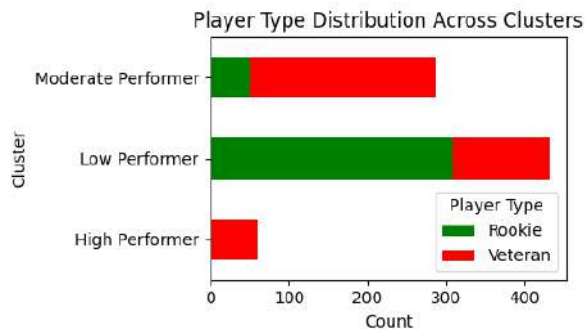


Figure 1: Player Type Distribution Across Clusters

Figure 1 illustrates the distribution of player types (veterans and rookies) across the clusters. Veterans dominate Cluster 2 (high performers), while rookies are more prevalent in Clusters 0 and 1 (moderate and low performers). This distribution highlights the performance gap between veterans and rookies, supporting the conclusion that experience significantly enhances a player's efficiency and contribution.

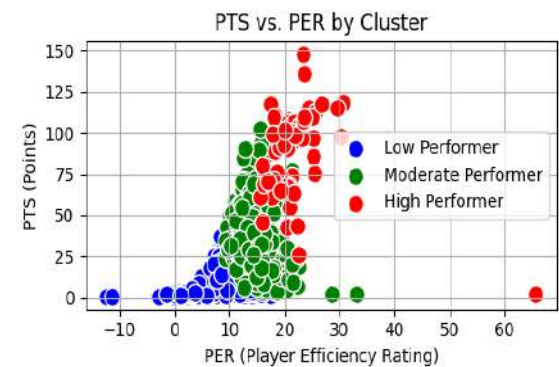


Figure 2: PTS vs. PER Scatter Plot across Clusters

Figure 2 displays a scatter plot illustrating the relationship between Points (PTS) and Player Efficiency Rating (PER) for players in each cluster. This visualization provides valuable insights into how scoring ability and efficiency vary across player groups:

Cluster 2 (High Performers): These players, primarily veterans, cluster in the upper-right quadrant, demonstrating high values in both PTS and PER.

Cluster 0 (Moderate Performers): These players exhibit average scores in both metrics, contributing meaningfully but not to the level of high performers.

Cluster 1 (Low Performers): This group of mostly rookies occupies the lower-left quadrant, reflecting low scoring and efficiency.

The scatter plot reinforces the performance patterns identified by the K-means clustering, with a clear distinction between high-performing veterans and lower-performing rookies.

K. DBSCAN Clustering Results

In addition to K-means, we applied DBSCAN (Density-Based Spatial Clustering of Applications with Noise) with parameters $\text{eps}=0.3$ and $\text{min_samples}=7$. These parameters were selected after extensive tuning, as they effectively captured the underlying structure of the dataset while maintaining a balance between meaningful cluster formation and noise reduction. The clusters identified by DBSCAN represent distinct player performance groups, with some outliers categorized as noise. DBSCAN Parameters are $\text{eps}=0.3$ value defines the maximum distance between two samples for one to be considered as about the other. A smaller `eps` was chosen to identify more compact clusters. min_samples value equals 7 which means the minimum number of points required to form a dense region (i.e., a cluster). The Silhouette Score of 0.507 suggests that the DBSCAN model achieved moderate separation between clusters, though not as strong as K-means. The DBSCAN algorithm identified three distinct clusters, one of which is categorized as Cluster -1 (Noise). The metrics used for evaluating player performance—Points (PTS), Player Efficiency Rating (PER), Win Shares (WS), Box Plus/Minus (BPM), and Value Over Replacement Player (VORP)—were calculated for each cluster to facilitate a meaningful comparison. Table 2 shows the average performance metrics for each identified DBSCAN cluster.

Cluster	PTS	PER	WS	BPM	VORP
-1 (Noise)	41.66	14.61	9.97	-0.70	2.84
0	10.79	10.28	1.34	-3.44	-0.16
1	1.79	1.40	-0.13	-10.18	-0.14

Table 2: Summary of K-means Clustering Results

Based on these metrics, the clusters were categorized as follows:

Cluster -1 (Noise): Despite being categorized as noise, this cluster contains high performers with strong PTS and PER values, likely representing outliers with significant team impact.

Cluster 0: Moderate Performers: Players in this cluster exhibit average metrics, like K-means Cluster

0, with moderate contributions but lacking the impact of higher-performing players.

Cluster 1: Low Performers: This group struggles in all metrics, with very low PTS and PER, indicating minimal impact on team success.

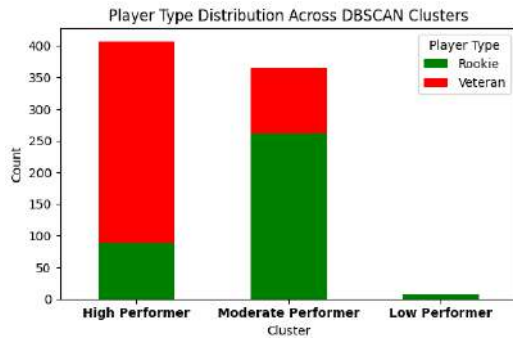


Figure 3: Player Type Distribution Across DBSCAN Clusters

Figure 3 illustrates the distribution of player types across DBSCAN clusters, showing that veterans are more prominent in Cluster -1 (Noise), while rookies dominate Cluster 1.

The distribution of player types across DBSCAN clusters reveals that most of the high performers in Cluster -1 (Noise) are veterans, while low performers in Cluster 1 are primarily rookies. This finding supports the conclusion that veteran players tend to outperform rookies in both scoring and overall efficiency.

Comparison of DBSCAN and K-means Clustering

The application of both clustering algorithms provided valuable insights into player performance; however, significant differences emerged between the two methods:

K-means offered clearer, more interpretable clusters that aligned well with expected performance categories. The separation between high, moderate, and low performers was distinct, and the clusters effectively highlighted the differences between veterans and rookies.

DBSCAN, on the other hand, excelled at identifying outliers (as seen in **Cluster -1**) but struggled to produce as clean and interpretable clusters as K-means.

While DBSCAN was effective at identifying noise and outliers, K-means was superior in categorizing players into distinct performance groups that aligned with the data's structure and the study's objectives. Thus, **K-means** is the preferred clustering method for this analysis.

The clustering results consistently highlight the superiority of veteran players across all key metrics. This is clearly illustrated by K-means Cluster 2, where the highest-performing veterans are grouped, showing outstanding scores in Points (PTS), Player Efficiency Rating (PER), Win Shares (WS), Box Plus/Minus (BPM), and Value Over Replacement Player (VORP). This observation resonates with existing research on the impact of experience in professional sports, particularly basketball, where seasoned players tend to exhibit superior decision-making abilities, heightened game awareness, and overall, more impactful play.

Veterans' superior performance is not just limited to scoring; their impact stretches across all facets of the game. Players in Cluster 2 demonstrated a unique ability to contribute to both offensive and defensive play, as indicated by their elevated BPM and VORP scores. These metrics provide a holistic measure of a player's ability to positively influence the game beyond just personal statistics, reflecting their contributions to team success. For instance, high WS values suggest that veteran players are more efficient in converting their play into wins for their teams, reinforcing the argument that experience directly correlates with winning outcomes.

Furthermore, the ability of DBSCAN to identify veterans as outliers with superior performance underscores the notion that veterans not only outperform their peers but also deviate significantly from the norm. This deviation signals their critical value in a team's strategy, as their consistent performance in high-stakes situations often becomes the differentiator in crucial moments of a game. Veteran players can, therefore, be seen as cornerstones in team composition, providing reliability, leadership, and a depth of experience that rookies have yet to acquire.

On the other hand, the clustering results provide a detailed narrative of the typical challenges faced by rookies, who were consistently grouped in low or moderate-performance clusters (K-means Clusters 0 and 1, DBSCAN Cluster 1). These findings reinforce the widely accepted understanding that transitioning from amateur or semi-professional levels to the NBA requires an adjustment period, often characterized by lower performance in key metrics like PER and WS.

Rookies, despite their raw talent and potential, often lack the refined skills and experience necessary to make significant contributions to their teams early in their careers. Metrics such as BPM and VORP further reflect their struggle to maintain a consistent positive impact on both ends of the court. This is indicative of a steep learning curve, where younger players face the dual challenge of adapting to the NBA's faster

pace and higher level of competition, as well as mastering the nuances of professional play.

However, the inclusion of rookies in moderate performance clusters also signals growth potential. While their performance may not yet match that of veterans, rookies often show flashes of brilliance that could, with time and experience, translate into higher levels of play.

The distinct performance gap between veterans and rookies revealed by both K-means and DBSCAN clustering suggests a strategic imperative for team managers to balance veteran leadership with rookie potential is crucial for long-term success. Veterans provide consistency, strategic understanding, and the ability to execute under pressure. Their high performance, as evidenced by the clustering results, proves that they are indispensable when it comes to steering teams towards consistent success. However, rookies, with their energy, fresh perspectives, and growth potential, represent the future of a team.

This balanced composition mirrors successful team-building strategies seen in professional sports, where mixing youth and experience creates a dynamic team. Veterans help maintain stability, offering a mentorship role that fosters the development of younger players. Meanwhile, rookies bring enthusiasm and a hunger to prove themselves, often injecting new energy into a team dynamic. The clustering results further validate this, as teams composed exclusively of veterans may lack long-term growth potential, while those relying solely on rookies may face immediate performance challenges.

Striking the right balance between these two groups could provide teams with both immediate success and sustained future growth, making it an essential consideration in player recruitment and development strategies.

V. CONCLUSION

This analysis sheds light on the undeniable value that experienced veterans bring to the game, offering a roadmap for teams looking to balance leadership with rising talent. The clustering results highlight that veterans remain central to a team's success due to their consistently high performance across critical metrics like Player Efficiency Rating (PER), Win Shares (WS), and Box Plus/Minus (BPM). Their wealth of experience allows them to contribute in ways that go beyond individual statistics, making them indispensable in high-pressure moments and crucial for converting efforts into wins. Conversely, while rookies may initially struggle to match the performance of veterans, they show growth potential, as seen in their moderate classification in performance clusters. These younger players bring enthusiasm, fresh energy, and a hunger to learn,

positioning them as the future pillars of any successful team. The application of both K-means and DBSCAN clustering methods affirms the importance of blending veteran experience with rookie potential. Teams that effectively combine seasoned leadership with rising talent not only set themselves up for immediate success but also ensure sustainable growth over the long term. This balance offers a strategic blueprint for player recruitment and development, ensuring that teams remain competitive in both the present and future seasons.

VI. ACKNOWLEDGMENT

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The Importance of Using Artificial Intelligence in Teaching Spoken English in Sri Lanka : A Study Based on Duolingo

Abstract— Artificial Intelligence (AI) refers to the simulation of human intelligence in machines that are programmed to think and learn like humans. Artificial Intelligence systems are capable of performing tasks that typically require human intelligence, such as visual perception, speech recognition, decision-making, language translation, and more. This research is to determine the role of Duolingo as an Artificial intelligence platform in English language teaching and to explore that it can play a major role in teaching speaking in English Language Teaching in Sri Lankan context. This study employs library research. The findings of the study reveal that Duolingo is a popular AI platform among individuals in many countries that offers more than 23 languages as options. It provides a positive impact on language learning with translation exercises, matching exercises, pairing exercises, listening exercises and speaking exercises. Speaking is one of the main skills to be improved when learning a language and findings of the study reveals that students are able to improve their speaking proficiency by using Duolingo. Moreover, Duolingo can indeed play a significant role in teaching spoken English in Sri Lanka.

Keywords— Artificial intelligence, Duolingo, Teaching speaking

I. INTRODUCTION

The integration of artificial intelligence (AI) in education has revolutionized the way knowledge is imparted and acquired, offering personalized, efficient, and scalable solutions to various challenges. Artificial Intelligence, in other words machine intelligence is the intelligence demonstrated by machines, in contrast to the natural intelligence displayed by humans and other animals. Some of the activities that are designed to do are speech recognition, learning, planning and problem solving” (Saleh, 2019). However, the integration of AI in education not only enhances personalized learning but also addresses traditional educational challenges with innovative and efficient solutions. According to Schmidt and Strasser (2023), digital technologies have become scientific and practical focal points in the English language teaching world. A case in point is Duolingo since it is a widely recognized language learning platform, while leveraging AI to offer an engaging, adaptive, and data-driven approach to language teaching. Therefore, this factor highlights its use of developing English language teaching in Sri Lanka, while paying attention to listening, speaking, reading, and writing. In various studies, the effectiveness of employing artificial intelligence education in Sri Lanka is discussed. In addition, Duolingo is demonstrated as one of the applications to do it. However, a lack of explanation on the importance of employing artificial intelligence in teaching spoken English in Sri Lanka based on the application Duolingo is identified. Hence, this factor has created a gap and the present study aims to address it, while answering the following two research questions: RQ1: What is Duolingo? and RQ2: Can Duolingo be used to teach spoken English in Sri Lanka?

II. METHODOLOGY AND EXPERIMENTAL DESIGN

This study employs library-based research methods and this is carried out through collecting data, scientific writing, or solving problems through in-depth study of relevant library materials. According to Zed (2004), in a library research, researchers directly engage with the textual sources and the research data consist of journals related to this research topic. This analysis will examine various journals, and previous research findings to establish a theoretical foundation for the current issue. In this study, concepts and theories are evaluated by drawing from a broad range of literature, particularly articles published in diverse scientific journals. After collecting all the data, the writers analyse it to draw the conclusion and to ensure accurate results, the writers employ content analysis techniques, which involve a detailed examination of written materials to provide descriptive explanations.

III. RESULTS

The preliminary results of the study provide answers for the two research questions. Hence, an explanation on the application Duolingo is given. Secondly, the evidences which justify Duolingo as an application which can be used to teach spoken English in Sri Lanka are presented.

In the present, various applications are created to assist humankind to complete various tasks. A case in point is learning a new language as it has become the norm in society due to globalization in the 21st century. Hence, Duolingo has become popular among individuals in many countries and it can be easily operated on Android, iOS, Windows, and the web. When an individual starts to use the application for the first time, Duolingo offers more than 23 languages as options. After selecting the necessary language, activating a daily goal should be also done and it leads to ask whether the user knows some elements of the language. If he/she has already learnt the language, a placement test is provided. However, an individual can also start with the basics if he/she is new to the language. It is evident that 5 types of impactful exercises are designed to create a positive impact on language learning: Translation exercises, matching exercises, pairing exercises, listening exercises, and speaking exercises. In addition, the application also attempts to motivate its user with pictures and sounds when he /she completes a daily goal.

Secondly, speaking is considered to be one of the essential skills to be improved when learning a language. Hence, an ESL teacher can guide students to enhance it by using the application Duolingo. When focusing on the Sri Lankan context, teaching speaking has become a challenge yet it highlights the use of Duolingo as a solution to overcome it.

In the research paper titled “The Utilisation of Duolingo to Enhance the Speaking Proficiency of EFL Secondary School Students in Saudi Arabia”, Alfuhaid (2021) demonstrates that

students are able to improve their speaking proficiency when Duolingo is used for a period of four consecutive months after selecting 28 students from a secondary school in Alqassim. Hence, speaking with confidence and improvement of fluency can be easily identified as effects of using Duolingo. In addition, focusing on speaking sub-skills, Alfuhaid (2021) highlights the manner in which the use of vocabulary and grammar is developed.

Secondly, Dearestiani et al. (2023) state that Duolingo can help learners to improve speaking skills in their research titled “Improving Students’ Speaking Skills by Using Duolingo Application” Therefore, 31 grade 8 students in SMP Negeri 35 Samarinda were selected and by employing pre-test and post-test, the necessary quantitative data were gathered.

Demonstrating the significance of the application, Fitria et al. (2023) investigate effects of Duolingo on speaking skills in their study titled “Duolingo Application for Advancing English Speaking Skills”. Hence, by selecting 20 students from a senior high school in Banda Aceh, Indonesia and conducting interviews and questionnaires, the researchers were able to collect necessary data to answer the following two research questions: “What are the students’ perceptions of using the Duolingo application in improving students’ speaking skills?” and “Which aspect of speaking do students perceive to be enhanced in learning by using the Duolingo application?”

IV DISCUSSION and CONCLUSION

Artificial Intelligence refers to the simulation of human intelligence in machines that are programmed to think and learn like humans. It encompasses a wide range of technologies and approaches, from machine learning to natural language processing and computer vision. The purpose of Artificial Intelligence (AI) is to create systems that can perform tasks that typically require human intelligence. These tasks include learning, problem-solving, language understanding, and decision-making. Artificial Intelligence can be highly beneficial for learning English by providing personalized and interactive experiences tailored to individual learners. Duolingo is a popular language learning platform that can be very helpful for learning English. It offers a gamified experience that makes learning fun and engaging. It includes speaking exercises that allow you to practice your pronunciation and comprehension and Duolingo can indeed play a significant role in teaching speaking skills in the context of English Language Teaching (ELT) in Sri Lanka. However, it may have ideally been part of a broader, more comprehensive language learning strategy.

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Comprehensive Analysis of Global Crude Oil Market Dynamics: Leveraging Hierarchical Clustering to Explore Country-Level Patterns and Strategic Decision-Making Trends

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Abstract— This study delivers an in-depth analysis of the global crude oil industry, focusing on unveiling complex patterns in production, exports, active oil rigs, and demand dynamics from 2012 to 2022. The study addresses the significant challenge of understanding how various factors, such as market conditions and geopolitical tensions, influence the industry. This study employs hierarchical clustering and robust statistical techniques to identify distinct groupings of countries based on their rig count dynamics, Production patterns, and Demand. The analysis reveals that these groupings are closely tied to market volatility and geopolitical events, offering a nuanced understanding of the global crude oil industry.

Additionally, the study examines varied consumption trends across different regions, highlighting the impact of divergent energy policies and economic growth trajectories. The findings suggest that these trends are crucial for stakeholders looking to make informed strategic decisions in fluctuating market conditions. By offering a comprehensive examination of the global crude oil market, this research contributes valuable insights that can aid in navigating the industry's inherent volatility. The study emphasizes the importance of comparative studies and reserve distribution analysis, suggesting that these approaches are essential for understanding the broader implications of global oil dynamics. Ultimately, this research provides a critical foundation for stakeholders to

enhance their strategic planning and decision-making processes within the complex global crude oil market.

Keywords: Global Crude Market Dynamics, Hierarchical Clustering Analysis, Crude oil Industry

I.INTRODUCTION

The global economy is largely supported by the global crude oil market, which impacts various sectors and financial environments. Its relevance is emphasized by enduring difficulties, such as geopolitical wars, demand variations, and environmental considerations, essential for transportation, heating, and electricity production. These factors affect investment strategy and supply chains by introducing volatility and uncertainty. In this dynamic environment, stakeholders must be alert and flexible. International crude oil prices considerably influence the world economy, production efficiency, balance of payments, social price levels, and international relations. Investing, industry participants, and governments encounter various difficulties when negotiating the complexities of the world crude oil market. Policymakers must balance environmental concerns with energy security, while industry stakeholders contend with supply chain dynamics, production costs, and market fluctuations. In addressing these complexities, stakeholders increasingly turn to

sophisticated data analysis methodologies, such as hierarchical clustering, to unravel intricate patterns within the global crude oil market. Hierarchical clustering methodology facilitates the categorization of countries based on their behavior across key metrics, including crude oil production, demand, exports, reserves, and active rigs. By identifying inherent similarities and differences among nations, hierarchical clustering offers insights into market dynamics, guiding investment strategies, supply chain management, and policy formulation.

In this study, we utilize an advanced and technologically-based approach, utilizing hierarchical clustering—a cornerstone of data science—to systematically analyze the complex dynamics of the world crude oil market. The underlying structure of complicated datasets is revealed by hierarchical clustering, distinguished by its hierarchical representation of data clusters. This strategy affords stakeholders a comprehensive understanding of market activities by organizing countries into hierarchical structures through the repeated merging of data points based on similarity measures. We extract deep insights into aspects of market dynamics, such as production trends, demand patterns, and export behaviors, by examining distinct clusters within each category. We then perform cross-category analysis to identify connections and interactions between clusters along different dimensions, which helps to decipher the complexity of the world crude oil market and provides stakeholders with useful information to guide strategic decision-making.

II. RESEARCH QUESTION

1. How can multi-dimensional cluster analysis unveil distinct groupings of countries based on their simultaneous behavior in the crude oil production, exports, reserves, and active rigs over the past decade?
2. What are the key drivers contributing to the formation of these clusters, and how have they evolved in response to geopolitical, economic, and environmental factors for different regions?

III. PROBLEM STATEMENT

The objective of this research is to utilize multi-dimensional cluster analysis to identify various clusters within the worldwide crude oil market and pinpoint the primary factors that have contributed to their development. The research aims to offer stakeholders practical insights for strategic decision-making in the dynamic global crude oil landscape by exploring the complex interactions between geopolitical, economic, and environmental issues. The complex interrelationships among oil demand trends, unconventional production dynamics, and the dynamic state of oil reserves highlight the necessity of a comprehensive analysis to comprehend the diverse dynamics of the world crude oil market. To effectively negotiate the obstacles and take advantage of the opportunities given by the global crude oil market, policymakers, industry stakeholders, and investors must have a thorough understanding.

IV. METHODOLOGY

The foundation of our research methodology is a combination of theoretical frameworks and empirical insights from influential works, including Matsumoto et al., Sancho et al., and Hennig. Our methodological approach is inspired by Sancho et al.'s cluster analysis of crude oils based on physicochemical properties, while Matsumoto et al.'s investigation of the production and export capacities of OPEC Middle East countries provides a crucial contextual understanding. We make sure that our analyses are methodologically sound and reliable by following Hennig's robustness criteria.

A. Utilizing Robust Methodology

We employ a robust methodology, adhering to Hennig's criteria to ensure the reliability and validity of our analyses. The integration of data from the OPEC repository—more specifically, datasets T31, T32, T35, T47, and T52—which offer thorough insights into important aspects of the crude oil market, is a key component of our methodology. From 2012 to 2022, these categories cover active rigs, crude oil production, export, demand, and reserves for both OPEC and non-OPEC nations. Our goal is to provide stakeholders with actionable insights by revealing significant patterns and interconnections within the data through rigorous preprocessing and cutting-edge statistical techniques.

B. Hierarchical Clustering

. Utilizing hierarchical clustering, the countries were grouped based on common standards, revealing hierarchical relationships and underlying patterns. Expanding on Hennig's framework, it facilitates visualization of grouping patterns and trends, offering stakeholders a comprehensive understanding of the global crude oil market dynamics.

C. Application and Interpretation of Code

To translate our methodology into actionable insights, Python's versatile libraries were leveraged, including pandas, matplotlib, seaborn, scikit-learn, and SciPy. We

commence by loading the dataset from the OPEC repository into a pandas Data Frame, encapsulating crucial parameters such as active rigs, crude oil production, export, demand, and reserves of both OPEC and non-OPEC countries from 2012 to 2022. Next, preprocessing is performed using the sci-kit-learn StandardAero module to handle missing values and standardize numerical features. We perform hierarchical clustering using the Agglomerative Clustering module, putting nations into groups according to similarities in their patterns of crude oil demand. By using the Ward linkage method, dendrograms are created that provide a visual representation of the hierarchical relationships between different countries. Furthermore, scatterplots are produced to illustrate clustering arrangements, enhancing the comprehensibility of our analyses. This data preprocessing, clustering, and visualization iterative process makes it easier for stakeholders to understand the complex dynamics that exist within the global crude oil market.

IV. RESULTS ANALYSIS

This study's data analysis, which makes use of hierarchical clustering methodology and strong statistical tools, offers a thorough overview of the worldwide crude oil industry. We uncover complex patterns and structures in the dataset using hierarchical clustering, descriptive statistics, and correlation analysis. The results provide logical organization by the research objectives, providing valuable insights into export behaviors, demand patterns, production trends, and other significant aspects of market dynamics. Cluster plots are one type of visual representation that improves the clarity of the data and helps to clarify the intricacies of the crude oil market.

In the analysis, the clustered countries were categorized into three distinct groups based on their rig count dynamics during the period from 2012 to 2022.

A. Active Rigs

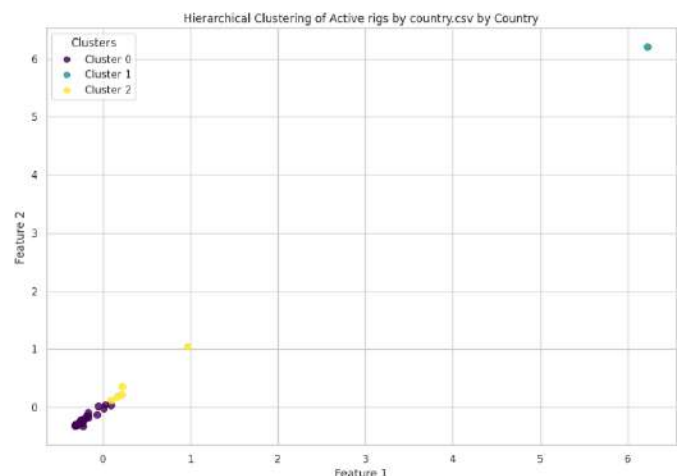


Fig.1 Active Rigs cluster plot – Hierarchical Clustering

Cluster 0, which included countries like Chile, Mexico, and Germany, had erratic rig counts, indicating varying investment levels that were contingent on market conditions. For example, Chile averaged 2 rigs each year during the time, maintaining a relatively modest rig count. In a similar vein, Mexico's rig count fluctuated, peaking at 114 rigs in 2012 and falling to 15 rigs in 2017, indicating the nation's reaction to changes in the market. States, India, and Canada were among the nations in the Cluster 1, which was distinguished by stable or rising rig counts, a sign of continued investment in drilling activities in spite of market swings. The United States, for instance, consistently invested in oil exploration and production as seen by its average annual rig count of 979 rigs.

Cluster 2 included countries with unstable rig counts, such as Saudi Arabia, Venezuela, and Iran, illustrating how economic volatility and geopolitical unrest affect oil rig operations. For example, the number of rigs in Venezuela varied significantly, from a low of 3 rigs in 2021 to a high of 221 rigs in 2014, which was indicative of the political and economic unrest in the nation.

These results offer insightful information about market trends and investment patterns in the worldwide oil and gas industry, assisting stakeholders in making decisions about risk management and investment strategies.

B. Crude oil demand

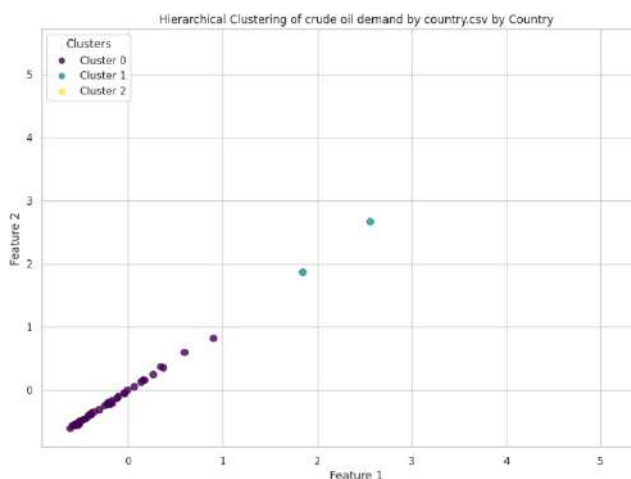


Fig.2 Crude oil demand cluster plot – Hierarchical Clustering

To analyze crude oil demand clusters, we integrate data from different regions and examine their consumption trends over time.

We observe different patterns of crude oil demand in Cluster0, which includes nations like Canada, France, and India. Demand in Canada varies; it fell noticeably from 2,440.3 thousand barrels per day (kb/d) in 2015 to 145.0 kb/d in 2022. This decline may have been caused by changes in the country's energy policies and economy. In a similar vein, India's demand has increased over time, hitting 4,771.6 kb/d in 2021 as a result of its growing economy and rising energy requirements.

Cluster 1 is made up of countries with high levels of demand for crude oil, like China and Japan. China's demand has grown steadily, with transportation demands, urbanization, and fast industrialization driving the country's increase from 9,793.0 kb/d in 2012 to 14,997.3 kb/d in 2021. On the other hand, demand in Japan is trending downward, falling from 4,679.9 kb/d in 2012 to 3,414.8 kb/d in 2021. This decline may be attributed to things like energy efficiency initiatives and a move toward renewable energy sources.

We find largely flat or dropping demand for crude oil in Cluster 2, which includes the US and Saudi Arabia. Influenced by variables such as increases in energy efficiency and a shift towards alternative energy sources, the United States demand, which was 18,680.2 kb/d in 2012, fluctuates but remains generally consistent at 20,034.0 kb/d in 2021. Saudi Arabia's efforts to diversify its economy and lessen its reliance on oil exports are reflected in the country's demand, which is also steady with only slight variations.

By highlighting the various consumption patterns within clusters that are impacted by energy legislation, economic development, and technology breakthroughs, we hope to provide investors, industry stakeholders, and policymakers with useful information.

C. Crude oil export

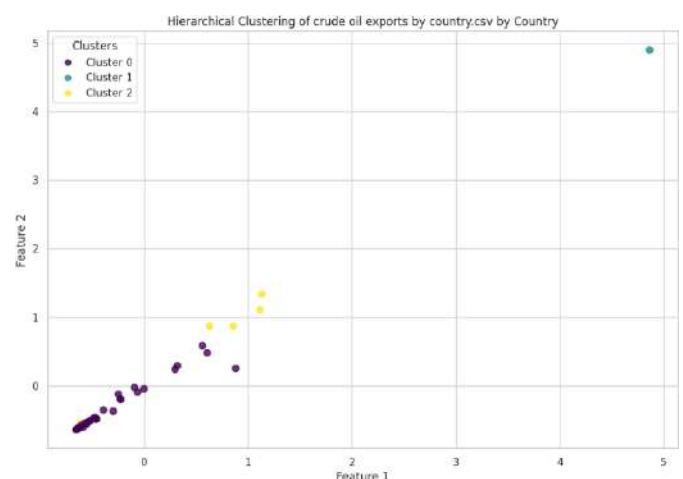


Fig.3 Crude oil export cluster plot – Hierarchical Clustering

To conduct a cluster-based analysis of crude oil exports from both OPEC and non-OPEC nations, we will look at export patterns in various regions and clusters.

The majority of the nations in Cluster 0 are non-OPEC nations including China, India, and Mexico. Crude oil exports from Mexico have been on the decline, falling from 1,333.1 kb/d in 2012 to 1,011.8 kb/d in 2022. This decline may have been caused by issues with production and changes in the market. China's exports, on the other hand, vary over time, which may be a result of changes in export laws and internal demand.

There are noticeable variations in export volumes in Cluster1, which is dominated by Saudi Arabia, a significant exporter to OPEC. The exports of Saudi Arabia vary from 7,556.8 kb/d in 2012 to 7,363.6 kb/d in 2022, perhaps because of geopolitical variables, OPEC agreements, and changes in global demand dynamics.

Cluster 2 consists of both OPEC and non-OPEC nations, such as the US and Canada. Thanks to developments in shale oil production and export infrastructure, the United States 'exports have increased significantly, from 67 kb/d in 2012 to 3,604 kb/d in 2022. Similarly, development in oil sands production and pipeline capacity is reflected in Canada's exports, which are expected to reach 3,350.2 kb/d in 2022.

Based on this analysis, we can see that different clusters have different export trajectories, which are driven by different factors such market dynamics, production capacity, geopolitical considerations, and regulatory regulations. For all parties involved in the global oil market to be able to predict changes and make wise decisions, they must comprehend these trends.

D. Crude oil Production

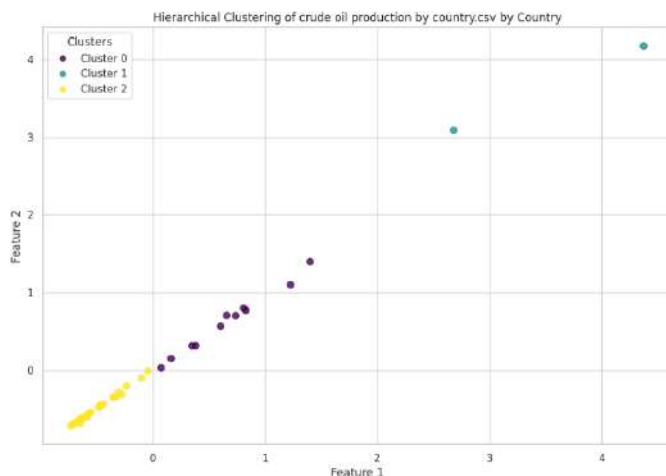


Fig.4 Crude oil production cluster plot – Hierarchical Clustering

A range of trends among the participating countries are shown by analyzing crude oil output across different groupings. Cluster 0 includes nations with varying production trends, including China, Mexico, and others. From 2,548 million barrels per day (mb/d) in 2012 to 1,622 mb/d in 2022, Mexico's output has steadily decreased. On the other hand, China's output has stayed largely constant over time, with only slight variations noted. Brazil and Iran are two other countries in this cluster with different production trajectories driven by geopolitical, technological, and economic considerations. Cluster 1, which includes major oil-producing countries like Saudi Arabia and the United States, has seen a significant increase in output. The United States' production has increased dramatically from 6.524 mb/d in 2012 to 11.887 mb/d in 2022, primarily due to breakthroughs in shale oil extraction methods. Over the same period, Saudi Arabia's production has been very steady, ranging between 9.763 mb/d and 10.591 mb/d.

Cluster 2 consists of a combination of non-OPEC and OPEC nations, including as the United Kingdom, Canada, and Norway. Aging oil fields and lower investment have led to diminishing production trends in Norway and the UK, whereas Canada has seen a slight rise in output, reaching 1.232 mb/d in 2022. Other nations in this group, including Indonesia and India, show a variety of production patterns that are impacted by the availability of resources and the state of the economy.

A comparative study of crude oil production amongst clusters offers important new perspectives on the dynamics of the world oil market, including investment trends, technological developments, geopolitical issues, and environmental regulations. To effectively traverse the complexity of the oil sector and make educated decisions, stakeholders must have a thorough understanding of these patterns.

E. Crude oil reserves

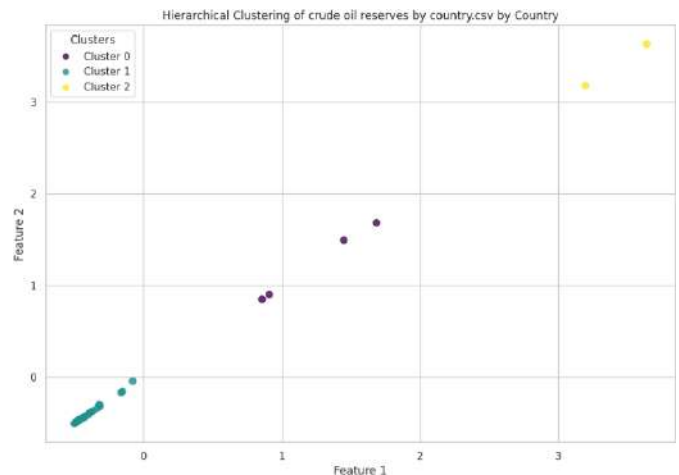


Fig. 5 Crude oil reserves dendrogram – Hierarchical Clustering

Understanding the distribution of crude oil reserves among various clusters helps to understand the endowment of resources in a region and how that affects the security of the global energy supply.

According to a study by Haider, Cluster 0, which includes key Middle Eastern oil-producing countries including Iran, Iraq, Kuwait, and the United Arab Emirates, exhibits sizable reserves. Iran's reserves, for example, were valued at 157,300 million barrels in 2012 and remained stable over time, reaching 208,600 million barrels by 2019. In a similar vein, Iraq's reserves, which peaked at 140,300 million barrels in 2012, held steady throughout the time, suggesting a steady supply of resources in the area.

OECD nations including the United States, Canada, and Mexico are included in Cluster 1, along with European countries like Denmark, Norway, and the United Kingdom. While some nations, like the United States, have seen impressive growth in reserves, others, like the United Kingdom, have seen reductions, according to research by Shafiee and Topal, suggesting that different nations' patterns in resource availability vary. As an example, the reserves of the United States increased from 30,529 million barrels in 2012 to

55,251 million barrels in 2022, whereas the reserves of the United Kingdom decreased from 2,800 million barrels in 2012 to 1,800 million barrels in 2022.

Countries in Asia and Latin America, including China, India, Brazil, and Argentina, are included in Cluster 2. With their substantial reserves, Saudi Arabia and Venezuela are important participants in this cluster. On the other hand, as Shafiee and Topal point out, worries regarding the depletion of fossil fuel reserves highlight the significance of sustainable energy policy and diversification initiatives in these areas. For instance, by 2022, Venezuela's reserves—which stood at 297,735 million barrels in 2012—had slightly declined to 303,221 million barrels, underscoring the necessity of strategic planning for ensuring the sustainability of resources over the long run.

environmental issues. For example, geopolitical tensions between China and its neighbors can influence investment choices and oil trade routes, while India's energy

V. CROSS CATEGORY ANALYSIS

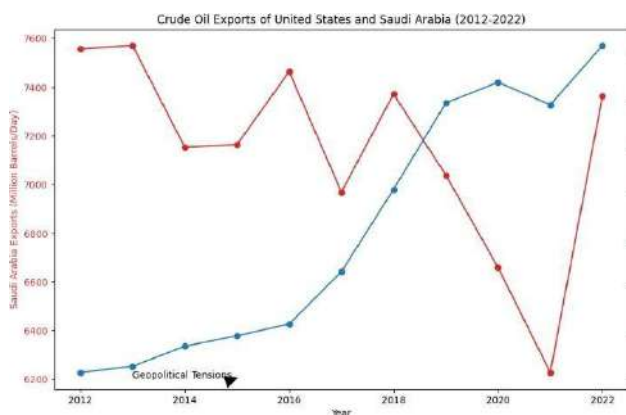


Fig. 6 United States and Saudi Arabia Export Plot

This intricate interaction is best illustrated by the divergent paths taken by major oil-producing countries such as Saudi Arabia and the United States. Saudi Arabia's key role as a leading exporter is a result of its substantial reserves and tactical OPEC membership, which give it considerable influence over the world's oil markets. Middle East geopolitical problems, like hostilities with Iran and unrest in the area, frequently affect Saudi Arabia's production choices, which in turn affects its export policies and market dynamics.

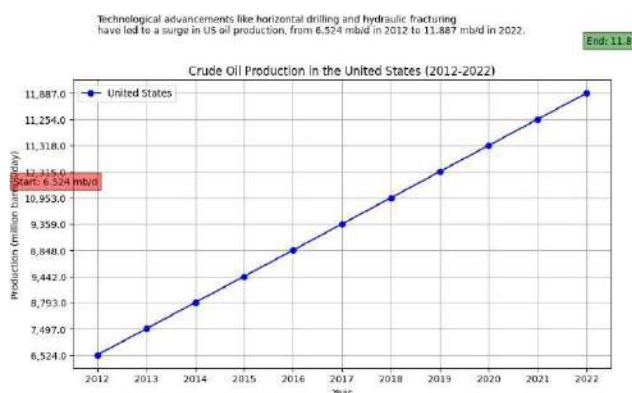


Fig. 7 Crude oil production United States (2012 -2022)

Major oil-producing countries' internal dynamics are always changing because of shifting geopolitical alliances, varying rates of economic growth, and pressing

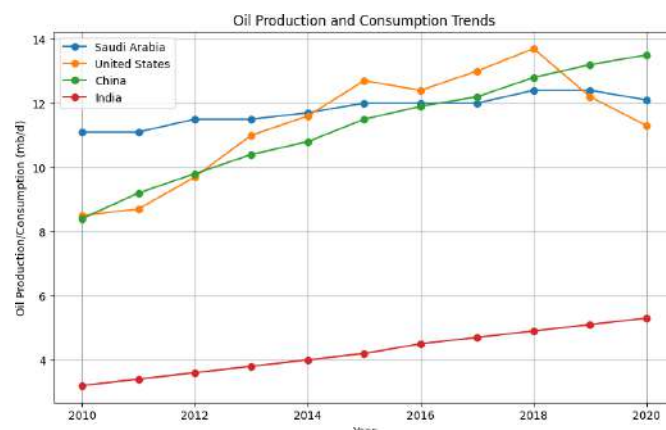
In contrast, technological advancements like horizontal drilling and hydraulic fracturing have caused a seismic shift in the US oil industry. These developments made it feasible to access enormous shale oil reserves, which propelled the nation to the forefront of oil exportation and production. Production surged from 6.524 million barrels per day (mb/d) in 2012 to 11.887 mb/d in 2022 because of the U.S. shale boom, revolutionizing the global oil dynamics. Economic variables, such as changes in oil prices and changes in the world's energy consumption, were crucial in determining how the major oil-producing countries developed. Increased investment in shale oil extraction propelled production growth in the United States during periods of high oil prices, changing the dynamics of global supply.

Major oil-producing countries have also been influenced by environmental factors more and more, especially when it comes to sustainability programs and emissions laws. Saudi Arabia has historically placed a higher priority on increasing oil production than the United States did on reducing carbon emissions and switching to cleaner energy sources. The oil industry adopted different investment strategies and long-term planning because of these divergent environmental policies, which had significant effects on the world's energy markets.

Fig. 8 Crude oil production and consumption trends of top countries

Like this, distinct geopolitical, economic, and environmental factors have shaped the growth and evolution of nations like China and India. China's swift urbanization and industrialization drove a strong increase in the country's need for oil, making international collaborations and investments in the acquisition of energy resources necessary. China's energy security policies and patterns of oil imports are also influenced by geopolitical tensions, such as territorial disputes in the South China Sea.

India has distinctive challenges to overcome in the areas of environmental sustainability, infrastructure development, and energy access. Growing oil consumption is a result of the nation's growing population and economy, which calls for investments in both domestic production and import infrastructure. To lessen its impact on the environment and achieve climate goals, India also aims to increase the use of renewable energy sources and lessen its reliance on fossil fuels.



landscape is shaped by technological advancements and economic reforms.

In conclusion, the development and evolution of clusters in the crude oil sector are intricate processes influenced by a wide range of interrelated variables. Through the

examination of nations and areas and the emphasis on numerical information, such as output figures and consumption trends, a more profound comprehension of the primary forces molding these clusters and their consequences for worldwide energy markets arises.

VI. CONCLUSION

The crude oil market is a crucial aspect of the global economy, impacting various industries and financial landscapes. Challenges like geopolitical conflicts, demand fluctuations, and environmental concerns underscore its significance, adding volatility to supply chains and investment strategies. Global crude oil prices influence international relations, production efficiency, and societal price levels, requiring a delicate balance between sustainability and energy security. Hierarchical clustering aids in understanding market dynamics, and guiding decision-making for investors, industry players, and governments. By combining theoretical frameworks with empirical data analysis, our research offers nuanced insights into production trends, demand patterns, and export behaviors, enabling stakeholders to navigate complexities effectively

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Assess the Health Impacts of Repeatedly Heated Cooking Oil Consumption Using AI Technology

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Abstract – The study focuses on recording, analysing and evaluating the constitution and the chemical composition of the coconut oil for cooking purposes which are used commonly in local restaurants and in the street food markets. Continuous reuse of repeatedly heated coconut oil which is used to fry food particles continuously poses a major health risk which effectively compromises the human immunity. The study uses coconut oil as the base since, coconut oil is commonly used by restaurant chains and street food markets for consumption in Southern Asia and analyse how the chemical composition breaks down while focusing on other factors such as the acidity and electro conductivity and determine how it affects the health, through employing machine learning algorithms. The study highlights the impact of the repeated usage of the coconut oil and its harmful effects on the human body by evaluating a trained model which is used to identify whether the coconut oil in question is suitable or not suitable for consumption further increasing awareness towards the usage of safer culinary practices and guidelines.

Keywords: coconut oil, model, health, harmful, consumption

Introduction – Cooking oil like coconut oil - oil that is extracted from coconut cream, is commonly used for consumption purposes especially in Southern Asian countries like Sri Lanka, India, Nepal, Pakistan and Bangladesh. It is frequently used for cooking purposes in households, hotels, restaurant chains and in street markets.

Though, the process of using the heated cooking oil is used to curb the cost of expenses, however, various studies have proven how the continuous usage of repeated heated oil to fry food particles have become a serious primary health concern due to the development of hazardous substance and chemical compositions, damaging vital human organs, raising the risk of cancer and chronic diseases such as diabetes, hypertension, and heart difficulties like strokes.

Cooking oils that are heated frequently have been shown to have negative health impacts. Heating oil several times causes its molecular structure to break down, which creates toxic substances like acrylamide, trans fats, and polycyclic aromatic hydrocarbons (PAHs). These harmful compounds have been connected to inflammation and oxidative stress, which are risk factors for a number of chronic illnesses. The practice of recycling frying oil persists despite the obvious concerns because of financial constraints and a lack of knowledge among customers and food suppliers.

Currently, experiments on regards to the consumption of repeatedly heated cooking oil are conducted on different animal models such as rats and mice where they have drawn conclusions on how it has impacted on the health on the models (Seema et al., 2023). While these studies provide valuable insights, there is a need for more comprehensive and precise methods to assess the health risks in humans. The study aims in utilizing advanced technologies, particularly artificial intelligence (AI), to provide promising solutions for this challenge.

By leveraging machine learning algorithms and extensive datasets, the research will analyse the chemical transformations and toxic by-products formed in cooking oils subjected to multiple heating cycles.

The importance of this study is valuable for policymakers, health professionals, and the food industry, ensuring that economic benefits do not come at the cost of public health.

Methodology – For the data collection process for the study to assess the health impacts of

repeatedly heated cooking oil, we will conduct a comprehensive data collection process involving 200 different food types and the commonly used coconut oil. The detailed steps for data collection are outlined below:

- A. Selection of food types – For this process we choose 200 diverse food types, including vegetables (e.g., carrot, tomato), grains (e.g., wheat flour), and combinations (e.g., wheat flour + sugar, wheat flour + sugar + salt).
- B. Preparation of oil samples –
 - 1) For each food type, prepare 250 ml of coconut oil in a frying pan.
 - 2) Fry 20 grams of a selected food type in the oil.
 - 3) After frying, separate a 50 ml sample of the oil and label it.
 - 4) Repeat the frying process with another 20 grams of the same food type in the same oil.
 - 5) Collect another 50 ml sample after the second frying.
 - 6) Continue this process until the food type has been fried five times, resulting in five 50 ml oil samples for each food type.
- C. Total samples – By following the above process for all 200 food types, we will obtain a total of 1,000 used coconut oil samples (200 food types x 5 samples each).

Results and discussion – For the analysis of the data collected, the oil samples are measured using specific parameters and then further analyse the data to determine the health impacts of repeatedly heated oil.

A. Chemiacal Analysis –

- 1) Measure the pH value of each oil sample to assess acidity changes.
- 2) Determine the level of 2,4-decadialenal, a harmful compound formed during the heating process, in each oil sample.

B. Data Processing –

- 1) Record all measured values and label each sample according to the food type and the number of heating cycles.

C. Data analysis –

- 1) Python Classification –
 - Utilize Python programming to analyze the collected data.
 - Apply machine learning classification algorithms to identify patterns and correlations between the number of heating cycles, food types, and the measured chemical changes (pH and 2,4-decadialenal levels).
- 2) Model development –
 - Develop predictive models to assess the safety of repeatedly heated oil based on the chemical composition and transformations.
 - Train the model using the collected data to classify oil samples as suitable or unsuitable for consumption.
- 3) Evaluation –
 - Validate the predictive model using a subset of the data to ensure accuracy.
 - Fine-tune the model parameters to improve predictive performance.

4) Outcome interpretation –

- Interpret the model's predictions to determine the safety thresholds for oil reuse.
- Provide recommendations on safe oil reuse practices based on the analysis.

Results –

A. Chemiacal analysis results –

- 1) The pH measurements of the 1,000 oil samples showed a consistent trend of increasing acidity with each subsequent heating cycle. The initial average pH value of fresh coconut oil was found to be around 7.4, which dropped to an average of 5.8 after five heating cycles.
- 2) The levels of 2,4-decadialenal, a toxic aldehyde formed during the heating process, significantly increased with each reuse. Initial levels in fresh oil were negligible, but after five heating cycles, the average concentration reached levels deemed hazardous according to established health guidelines.

B. AI model prediction –

- 1) The machine learning classification algorithms successfully identified patterns correlating the number of heating cycles and the chemical changes in the oil samples.
- 2) The predictive model, trained on the dataset, classified oil samples with high accuracy (90%) as suitable or unsuitable for consumption based on the pH value and 2,4-decadialenal levels.
- 3) The model determined that coconut oil could be safely reused up to two times without exceeding safe thresholds for acidity and 2,4-decadialenal levels. Beyond two heating cycles, the

risk of adverse health effects increased significantly.

C. Health impact analysis –

- 1) The analysis indicated that the continuous reuse of cooking oil leads to the accumulation of harmful compounds that pose serious health risks. Specifically, the increased acidity and 2,4-decadienal levels were linked to oxidative stress and inflammation, which can lead to chronic diseases such as cancer, diabetes, and cardiovascular conditions.

- 2) The findings suggest that economic benefits from reusing oil come at the cost of increased health risks, underscoring the need for regulated practices in food preparation environments, especially in regions where this practice is prevalent.

Discussion –

A. Significance of findings –

- 1) The results of this study provide empirical evidence supporting the health risks associated with repeatedly heated cooking oil. The chemical analyses and AI model predictions offer a clear picture of how oil degradation occurs and the associated health impacts.
- 2) This research bridges a critical gap by using AI to analyze large datasets and make accurate predictions, offering a more comprehensive understanding than traditional methods.

B. Implications for public health and policy –

- 1) The study's findings highlight the urgent need for public health guidelines regulating the reuse of cooking oils. Policymakers should consider setting clear limits on the number of times cooking oil can be reused to protect public health.
- 2) Food safety authorities should promote awareness campaigns to educate consumers and food vendors about the risks of reusing cooking oils and the importance of adhering to safe practices.

C. Practical recommendations –

- 1) Based on the study's findings, it is recommended that cooking oil should not be reused more than two times to minimize health risks. Food establishments

should implement protocols to monitor the reuse of cooking oils and ensure compliance with safety standards.

- 2) The development and deployment of AI-based monitoring systems in food preparation environments can provide real-time assessments of oil quality, helping to prevent the use of degraded oils and ensuring food safety.

D. Future research directions –

- 1) Further research should explore the health impacts of repeatedly heated cooking oils with different compositions and in different culinary contexts. This could help generalize the findings across various cooking practices and regions.
- 2) The integration of more advanced AI techniques, such as deep learning, could improve the accuracy of predictive models and offer more nuanced insights into the chemical transformations and health impacts of repeatedly heated oils.

Conclusion – This research comprehensively assessed the health impacts of repeatedly heated cooking oil consumption using AI technology. By collecting and analysing data on 200 food types and 1,000 oil samples, the study demonstrated the significant health risks posed by the continuous reuse

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Integrating AI System in Urban Areas for Real-Time Segregation and Disaster Mitigation

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Abstract – The transformation of AI technology into the urban setting has a potential to revolutionize the way we segregate waste and respond to disasters in real time. The objective of this research is to develop a Convolutional Neural Network (CNN) that can be trained on annotated datasets for classification of waste types such as paper, plastic, metal, and food. Kaggle was used to source data while CVAT was utilized for annotation. This model shows good performance in both training and validation phases thus it can be used in real-time applications. In this document, we outlined pre-processing, training evaluation as well as integration processes which map the implementation path for such systems in cities. The findings show that the system can greatly enhance efficiency in waste management and reduce disaster response time.

Keywords: AI, Waste Segregation, CNN

Introduction

Urban areas face significant challenges in waste management and disaster response, with traditional methods often proving inefficient and slow. The conventional ways of doing things in such instances have been very ineffective and slow. These ineffectiveness's do not result only in environmental pollution but also delayed mitigation of disasters, which poses substantial risks to the health and safety of the public. The world, therefore, in this increasing wave of urbanization and surging volume of wastes, needs innovative solutions to make these critical processes more efficient and effective. AI systems integrated into urban infrastructure open a fresh avenue toward such set of challenges. This will revolutionize real-time waste segregation and disaster management with advanced machine learning techniques—Convolutional Neural Networks, in the main. Thus, this work focuses on developing a robust CNN model for the classification of various waste types and its seamless integration into a real-time monitoring system, in pursuit of which lies great potential to improve urban waste management and disaster response mechanisms.

Methodology

The methodology involves several key steps:

1. **Data Collection and Preprocessing:** Data was collected from [Kaggle](#) and annotated using [CVAT](#) into four categories: paper, plastic, metal, and food.
2. **Model Training:** A CNN model was trained using the annotated dataset. The training process involved tuning hyperparameters to achieve optimal performance.
3. **Model Evaluation:** The model's performance was evaluated using training and validation datasets. Metrics such as accuracy and loss were tracked to ensure the model's effectiveness.
4. **Integration into Real-Time System:** The trained model was integrated into a real-time

monitoring system for urban waste management and disaster mitigation.

Data Acquisition and Preprocessing:

Model Training:

We developed a Convolutional Neural Network (CNN) model for waste classification. The architecture of the CNN included several layers: convolutional layers for feature extraction, pooling layers for dimensionality reduction, and fully connected layers for classification. The model was trained using the annotated dataset, with the following hyperparameters:

- **Learning Rate:** 0.001
- **Batch Size:** 32
- **Epochs:** 50

Example of Annotated Images

The annotated dataset used for training the CNN model includes images that have been manually labeled into four categories: paper, plastic, metal, and food. Below are examples of the annotated images:

Figure 1: Annotated Image Examples

1. **Paper:** This image displays an example of a paper waste item, annotated as 'paper'.



Figure 1. Paper

Source: KDU IRC 2024

2. **Plastic:** This image displays an example of a plastic waste item, annotated as 'plastic'.



Figure 2. Plastic

Source: KDU IRC 2024

3. **Metal Error:** This image illustrates an example of a metal waste item, annotated as 'metal'.



Figure 3. Metal

Source: KDU IRC 2024

4. **Food:** This image depicts an example of a food waste item, annotated as 'food'.



Figure 4. Food

Source: KDU IRC 2024

The dataset was split into training and validation sets with a ratio of 80:20. Data augmentation techniques such as rotation, scaling, and flipping were applied to enhance model generalization and prevent overfitting.

Model Evaluation:

The performance of the model was evaluated using

metrics such as accuracy, precision, recall, and F1-score. Training and validation loss and accuracy were monitored throughout the training process to ensure the model's performance and to detect any signs of overfitting or underfitting. The evaluation results showed high accuracy in classifying the waste categories, indicating the model's effectiveness.

1) Integration into Real-Time Monitoring System

While the integration into a real-time waste management system is a crucial step, it remains as planned future work. The envisioned integration workflow will involve:

1. **Data Acquisition:** Continuous collection of waste images from urban areas.
2. **Data Preprocessing:** Real-time preprocessing of incoming data to match the format and structure of the training dataset.
3. **Model Inference:** Applying the trained CNN model to classify the incoming waste images.
4. **Data Logging and Monitoring:** Storing the classification results in a database and monitoring the system's performance.

2) Current Implementation and Future Work

Currently, our focus has been on developing and validating the CNN model for waste classification. The steps completed so far include:

1. **Data Collection and Annotation:** We collected a comprehensive dataset from Kaggle and manually annotated it using CVAT, categorizing waste into four types: paper, plastic, metal, and food.
2. **Model Development and Training:** We developed a CNN model with layers for feature extraction, dimensionality reduction, and classification. The model was trained with optimal hyperparameters and evaluated for accuracy, precision, recall, and F1-score.
3. **Model Validation:** Extensive validation showed high accuracy in classifying waste types, demonstrating the model's effectiveness.

Future work will focus on integrating this trained model into a real-time monitoring system, adhering to the planned workflow, to enhance urban waste management and disaster response capabilities.

Results and Discussion

The training and validation graphs indicate that the model achieves high accuracy and low loss, demonstrating its robustness. The training accuracy consistently improves, while the validation accuracy remains stable, indicating good generalization. The loss metrics show a similar trend, with training loss decreasing and validation loss stabilizing.

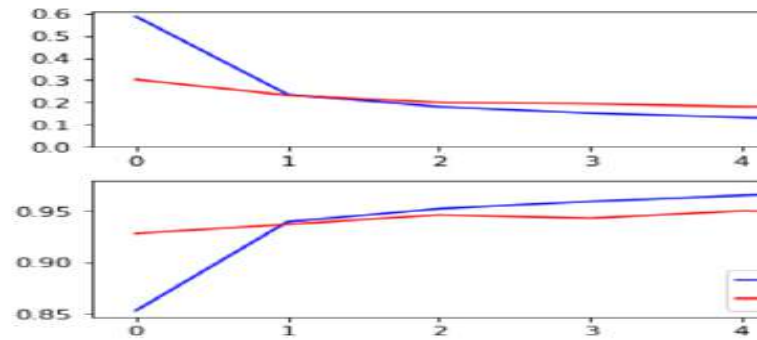


Figure 5. Training and Validation

Source: KDU IRC 2024

The pie chart below shows the distribution of waste categories in the dataset, highlighting the predominance of paper, followed by food, plastic, and metal. This distribution is crucial for model training as it reflects the real-world scenario where paper waste is most common.

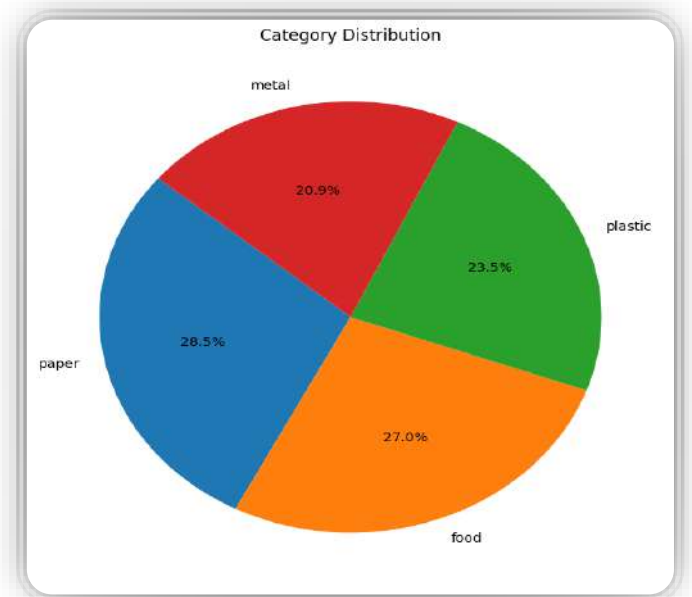


Figure 6. Pie chart of waste distribution in the dataset

Source: KDU IRC 2024

4. **Integration into Real-Time System:**

Implementing the trained model into a real-time system for monitoring and managing waste segregation and disaster response.

Workflow Explanation

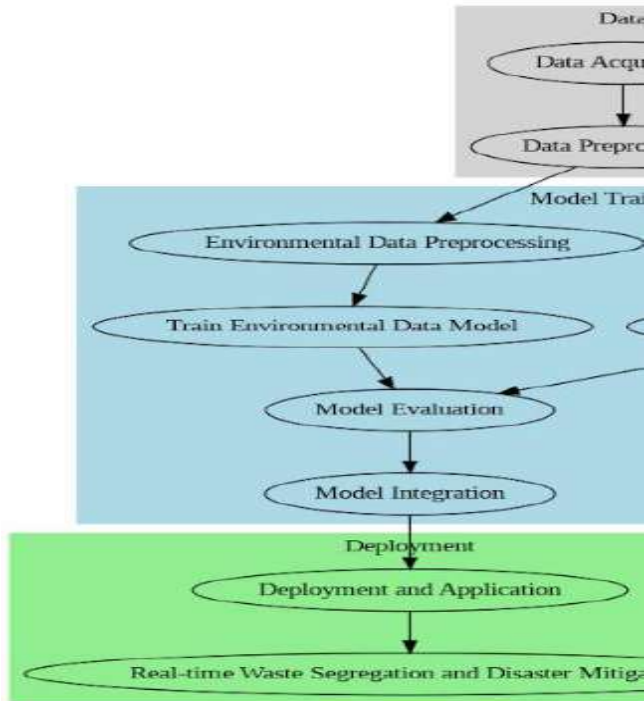


Figure 7. Workflow for integrating the AI system

Source: KDU IRC 2024

The workflow for integrating the AI system into urban areas involves several stages:

1. **Data Collection & Preprocessing:** Data acquisition from various sources followed by preprocessing to clean and annotate the data.
2. **Model Training:** Training the CNN model on the preprocessed data to classify different types of waste accurately.
3. **Model Evaluation:** Assessing the model's performance using various metrics and ensuring it meets the required accuracy and reliability.

Conclusion

The application of AI systems in urban environments for real-time waste segregation and disaster mitigation presents a transformative approach to addressing critical challenges in waste management and emergency response. The Convolutional Neural Network (CNN) model developed in this study demonstrates high accuracy and effectiveness in classifying various waste types, underscoring its potential utility in practical, real-world scenarios. Although the integration into a real-time monitoring system is planned for future work, the current results are promising and suggest that such an implementation could significantly enhance operational efficiency and responsiveness. Moving forward, our efforts will concentrate on expanding the dataset to include a wider variety of waste types and refining the model to improve its accuracy and robustness. Additionally, future research will explore the deployment of this system in diverse urban settings to validate its scalability and adaptability, ultimately contributing to more sustainable and resilient urban management practices.

References

- Kaggle. Garbage Classification Dataset. [Link](#)
- CVAT. Computer Vision Annotation Tool. [Link](#)

Exploration of the Problems Faced by Cargo Operations in SriLankan Airlines

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Abstract — In the dynamic realm of Supply Chain and Logistics in the digital age, this study aims to explore the operational challenges within Sri Lankan Airlines Cargo Operations and propose strategic solutions to enhance operational efficiency. The study focuses on three pivotal areas: Documentation, Handling Perishable Cargo, and Digitalization. This qualitative study employs thematic data analysis, gathering data by conducting interviews with the Sri Lankan Cargo Operations Management team where a purposive sampling technique was used. Documentation bottlenecks were discovered, emphasizing excessive paperwork, rigorous evaluations prone to human errors, and communication gaps leading to fines. For perishable cargo, challenges such as the absence of a cold chain management system, limited freezer areas, and inadequate storage were identified. Digitalization barriers include outdated tracking systems, lack of cargo checking machines and communication challenges during SLACDP system implementation. The study highlights the urgent need to streamline operations and adapt to the digital era. Proactive recommendations support adopting e-AWB, electronic signatures, and unified communication platforms to revolutionize documentation processes. Upgrading the automated temperature monitoring system is proposed to ensure real-time data alerts for perishable cargo. Collaborations with airlines and freight forwarders are recommended for a steady supply of containers, overcoming space constraints in the cargo warehouse. The need for a modern, cloud-based cargo tracking system and automation tools is emphasized, recognizing the current technological constraints in the developing country context. For future research, the study suggests exploring diverse samples, conducting quantitative studies, and extending the focus beyond a single airline or country.

Keywords— operational efficiency, digitalization, documentation, perishable cargo

I. INTRODUCTION

In the dynamic landscape of the aviation industry, cargo operations play a pivotal role in ensuring the efficient and timely transportation of goods across the globe. Air transportation is a cornerstone of the modern economy

due to its integrated services, safety, speed, dependability, efficiency, and convenience. It significantly contributes to economic development, offering flexibility for suppliers and customers through rapid deliveries in time-sensitive situations (Lenin, 2015). The International Air Transport Association (IATA, 2023) reports that cargo operations now account for 20% of airline revenue, double the pre-pandemic average. Air cargo enhances supply chain efficiency, supports Just-In-Time delivery systems, and ensures swift delivery of high-value products, especially for international online shopping orders (Vasantha, 2019).

Air cargo transportation involves various stakeholders, including airlines, cargo terminal owners, ground handlers, freight forwarders, domestic transport providers, and customs agents. These parties handle cargo preparation, loading, unloading, and transfers between storage and transportation facilities, ensuring compliance with customs and regulatory procedures (Vasantha, 2019; Yadav et al., 2022).

This study focuses on Sri Lankan Airlines to explore its air cargo operations and the challenges faced by its Cargo Operations unit. As the exclusive ground handling agent at Bandaranaike International Airport (BIA), Sri Lankan Cargo manages cargo movements under the oversight of multiple authorities. Since its inception in 1979, Sri Lankan Cargo has supported the nation's export industry, operating 27 modern Airbus planes and serving 49 destinations worldwide (Sri Lanka.com, 2020). As of 2023, Sri Lankan Airlines operates 56% of its capacity from Colombo and handles 31% of the country's exports. During the COVID-19 pandemic, Sri Lankan Cargo provided critical logistics solutions, especially for medical supplies (Sri Lanka.com, 2020). This paper aims to identify the current issues faced by Sri Lankan Cargo Operations in handling air cargo movements in Sri Lanka.

A. Research Problem

Sri Lanka's Logistics Performance Index (LPI) is relatively low. The LPI, developed as an interactive benchmarking tool, helps nations identify opportunities and challenges in trade logistics performance and suggests

ways to improve. The LPI evaluates six dimensions: international shipments, logistics competence, tracking and tracing, and timeliness.

This research focuses on the customs dimension, crucial for assessing the efficiency of the clearance process, including speed, simplicity, and predictability of formalities by border control agencies (World Bank, 2023). Additionally, the infrastructure dimension is considered to study the impact of digitalizing air cargo operations. Timeliness is another important aspect as cargo clearance issues can lead to delays in shipments reaching their destinations on schedule. According to IATA Cargo 2022 data, Sri Lanka's aviation import dwell time (milestones NFD to DLV) averages 3.0 days, compared to lower mean times in many other

customs, infrastructure, of Sri Lankan Airlines.

Specific Objectives

1. To identify the problems in the documentation process of SriLankan Airlines Cargo Operations Unit.
2. To identify the challenges faced by SriLankan Airlines Cargo Operations Unit when handling perishable cargo.
3. To find out the challenges of digitalization of air cargo operations affecting the SriLankan Airlines Cargo Operations Unit.

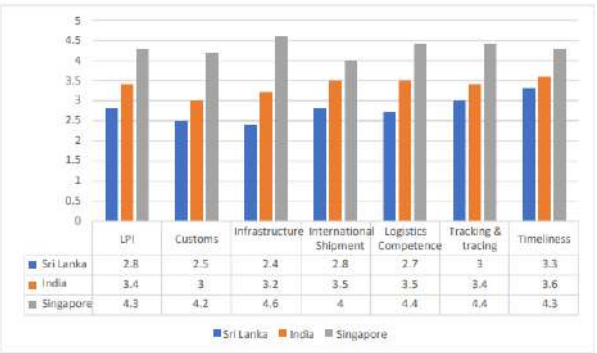
II. METHODOLOGY AND EXPERIMENTAL DESIGN

The research design, guided by the Research Onion model (Saunders et al., 2007), involves a deductive approach with an interpretivism philosophy. The case study research strategy is adopted, focusing on the Cargo Operations Division of Sri Lankan Airlines. The target population comprises the Cargo Operations management team of Sri Lankan Airlines. A purposive non-probability sampling technique is applied, resulting in a sample size of 12 participants. In-depth interviews and observations were conducted to gather first-hand information, where seven key respondents contributed to the primary data collection process. The questions regarding the documentation issues focused on the current process, instances of paperwork delays, impact on efficiency, suggestions for digital solutions, improvements in stakeholder communication and the processes. Regarding digitalization, the researchers questioned the extent of digitalization and identified challenges and factors that lead to operational delays at terminals and so on. When questioning about handling perishable cargo, researchers delved into seeking insights on crucial factors for successful handling and potential areas for improvement by questioning about the challenges, adherence to IATA standards, and factors contributing to challenges like temperature control systems and sensitive cargo clearance. Secondary data is obtained from journal articles, organizational history, annual reports, and other published records, providing a contextual backdrop for the study.

III. LITERATURE REVIEW

A. Documentation Process

Customs clearance procedures are a major regulatory challenge and barrier impacting the efficient flow of cargo across the world. (Chang & Debowski, 2005; Vasantha, 2019)In air cargo clearance it is important to maintain accurate documentation, as even small



countries, indicating fewer delays at ports and airports.

Figure 1.1: Overall Dimensions Scores of Singapore and India compared to Sri Lanka
Source: World Bank (2023)

Figure 1.1 compares the LPI scores of Sri Lanka with leading performers Singapore and India in 2023. Sri Lanka underperforms in all six dimensions, particularly in infrastructure, where it scores the lowest at 2.5. Despite technological advancements, Sri Lanka's logistics performance has declined compared to previous years. The second lowest score for Sri Lanka is in the customs dimension, which is central to this study's focus on cargo clearance issues at Bandaranaike International Airport (BIA).

To improve its LPI and stabilize its rank, Sri Lanka needs to address problems related to customs, timeliness, and infrastructure that affect cargo clearance at the airport. BIA, a major airport in Sri Lanka, handles 250,000 MT of cargo daily, and enhancing its cargo handling and clearance processes is vital for improving the country's overall logistics performance.

B. Research objectives

Primary Objective:

To explore the problems faced by the Cargo Operations

documentation errors can lead to additional costs with delayed shipments. (Swan, 2015) Airlines, airports, customs, ground and cargo handling businesses, shippers, and consignees are among the many players in the air cargo industry. Up to 30 separate documents are generated for airfreight shipments. Manual verification is used in the verification of paperwork and papers, booking, tracking, and tracing. (I. Poleshkina, 2021) According to SriLankan Cargo Centre, the customs clearance process requires submitting various documents like commercial invoices, packing lists, Original Airway bills, and Freight arrival notices issued by SriLankan Cargo and any regulatory approvals. (Chang & Debowski, 2005) pointed out that pre-clearance, or submitting necessary documents before the flight's arrival, is essential to ensure next-day delivery but adds another layer of complexity. New security requirements after 9/11, like providing more details about the shipment before loading and original supporting documents, have worsened these clearance issues. (Chang & Debowski, 2005) This entails the smooth flow of preparation and clearance of cargo. The clearing agency must arrange additional customs papers to clear the cargo once they have received the necessary paperwork from the cargo handling agent. Otherwise, the shipment may incur fines, and the clearing procedure will be delayed. To ensure efficient freight clearance, a strong documentation process is essential (Sritharan, 2017) Most of the time, during air cargo delivery, products are at the point of origin or destination. This is mostly due to the need to comply with airport formalities such as security inspections, document registration and verification, customs clearance of products, veterinary and phytosanitary checks, packing, labelling, and so on. (Ahmad et al., 2021) Delays at border crossings and ports caused by lengthy, complex procedures and excessive paperwork have created a negative impact on trade mainly in terms of time and cost (Wickramarachchi, et al., 2015). Divyaranjani et al., (2023) noted that when running logistics operations in the Emirates, a lot of paper is still used. Despite the introduction of the e-freight system, which has not been properly integrated or performed. Air cargo also faces issues with misrouting or losing shipments, as the complex network of handoffs provides opportunities for error. (Charoensiriwath & Hongdalud, 2007) In this case, 21 documentation is important because it includes the contract of carriage and the conditions related to shipping. (RGX Online 2016.)

B. Handling Perishable Cargo

According to the International Civil Aviation Organization (ICAO) and the International Air Transport Association (IATA), it is necessary to use properly qualified workers when transporting perishable and hazardous materials from the place of origin to the destination. The goal of packaging items

for transportation is to prevent potential damage, enable correct handling, and achieve effective space utilization inside the transport unit while allowing for the stability of the transport vehicle (Daniel et al., 2016). Sri Lanka is a major exporter of perishable goods like seafood, fresh produce, and live animals, as well as general cargo exports like clothing and clothing manufacturing raw materials, all made possible by SriLankan Airlines and other international airlines that fly to and from Sri Lanka. Therefore, in the cargo handling terminals, the airline upholds recognized ground handling requirements. BIA currently has a single terminal for handling domestic and international services. For Sri Lanka to compete in the global market and attract additional aircraft traffic to grow Sri Lanka as a transshipment hub, it is problematic to ensure that products are handled to retain the intended quality standards for perishable cargo (Premarathne, et al., 2021). Congestion in the warehouses during peak demand periods like the summer and shopping festivals makes it difficult to make room for new goods, this could cause damage to perishable goods. (Divyaranjani et al., 2023) Early literature by Abraham (2009) focused on meeting time limitations and optimising vehicle routing for picking up and delivering perishable products to an airport in South India, by building a mathematical model and a solution methodology. (I. O. Poleshkina, 2020) claims that handling perishable cargo at airports is a common challenge, particularly in Russia. According to a study on mango supply networks, 90% of perishable imports pass via Moscow airports, which lack the facilities and modern technologies needed for effective handling and thus cause delays. To cut down on paperwork and overall handling time, a blockchain system and e-workflow are suggested. In Nigeria, (Uchendu, n.d.) discovered that effective freight delivery is positively impacted by cargo handling equipment. Enhancing equipment performance and making up for problems that reduce efficiency are among the recommendations additionally suggested. To speed up document verification, 22 enhance customs clearance and improve monitoring, tracking and control of perishable items, (I. Poleshkina, 2021) also suggests implementing blockchain and IoT technologies in air transport supply chains. (Tanuputri, 1970) examined the importation of perishable products at major Indonesian ports and compared the customs clearance periods between ports. To increase effectiveness, it is suggested that infrastructure be improved, the Indonesian National Single Window be implemented, and private stakeholders collaborate. In summary, these papers recommend improving infrastructure and technology, increasing efficiency, optimizing processes, and enhancing collaboration to better handle perishable cargo, especially at airports. Moreover, the handling of perishable items in supply chains for air transport can

be streamlined with the help of automated systems, electronic processors and blockchain technology.

C. Digitalization of air cargo operations

Even though the cargo process has been somewhat digitalized, as a country we do not fully embrace the high-tech capability of cargo management. According to Gardy (2016), digital solutions for airport operations include flow monitoring and management, processor automation, group decision-making, predictive and preventative solutions and customer interaction to increase both commercial and technical efficiency. The utilization of equipment including X-ray machines and cargo systems that allow for the tracking, manifesting, and release of customer cargo has led to the classification of the BIA Cargo terminals as semi-automated at this time (Premarathne, et al., 2021). Modern information technology and automation are still crucial for overcoming cargo clearance problems, as evidenced by more recent studies. The industry's activity has changed as a result of the resurgence of commercial passenger air travel, leading to capacity limits, decreasing profits, and increasing competition. As a result, the future lies toward further process automation and customer-friendly service improvements. There arises an issue as to how cargo clearance will manage the enhancement of the level of automation and digitalization of processes at airports (Weerasooriya, 2023). A study (Poleshkina, 2021) assessed and summarized the world practice of using blockchain technology and suggested a system for its establishment on par with the IoT and Smart Contract 23 Technologies which would increase transparency for sharing data between stakeholders, minimizing service delays and optimizing the use of airport resources. According to (Liew Qian, 2022), Malaysian airports have improved visibility and productivity by digitally transforming airside operations with the help of technology like the Digital Integrated Airside Services system. Regional airports are the subject of a (Plško & Remencová, 2022) study on digital transformation, and it has been discovered that while they have great funding difficulties, they may greatly benefit from technologies that increase productivity while minimizing cost. (Zaharia & Pietreanu, 2018) describes how innovations and operational improvements at airports are made possible by technology like total airport management and collaborative decision-making at airports. (Kovacikova et al., 2021) makes comparisons between Slovak airports and the best in Europe, claiming that despite their current lack of digitization, Slovak airports must adopt innovations to compete. A study (Lenin, 2015b) examines potential operational issues for the company and focuses on the processing of air freight, notably concerning Emirates SkyCargo. It mentions that Emirates Sky Cargo has launched a system dubbed "Sky Chain" - a thorough end-to-end IT cargo

management solution that boosts business effectiveness throughout the airfreight life cycle. A few of Sky Chain's features include AWB Management, figuring out the most affordable and efficient ways to get there, capacity management, flight load planning, cargo revenue planning, management of flight disruptions, ad hoc requests, stock management, etc. Several papers explore how new technologies can streamline complex processes and reduce inefficiencies.

IV. KEY FINDINGS

This section breaks down the challenges within the three key areas studied providing specific insights gathered from interviews. Thematic analysis is employed to analyse qualitative data collected, by aiming to derive meaningful insights from the data, identifying patterns and emerging concepts related to the challenges faced by Cargo Operations in the digital age.

Table 1 tabularizes the findings gained by conducting interviews with the SriLankan Cargo Operations team who are given the below respondent IDs:

D1 Cargo Duty Manager – Admin, D2 Cargo Operations Business Development Manager, D3 Cargo Supervisor; (System supervisor), D4 Dangerous Goods Manager, D5 Duty Airport Manager – Cargo, D6 Cargo Officer (Tracing), D7 Cargo Officer (Mails)

Firstly, regarding *documentation* issues, most of the interviewees expressed their concern about the involvement of excessive paperwork. This was highlighted by many responses; documents such as AWB and cargo manifests are rigorously evaluated for any missing information in important sections such as SI, Handling information and SHC, and any mismatches in the soft and hard documents caused by human errors are also checked manually. Another challenge is the communication and coordination issues which were understood by the systematic difficulty in documentation system updates. System corrections within the SriLankan Cargo are said to not reflect promptly in the SriLankan Customs, leading to the consignee paying fines. Interviewees commented on the possibility of fraud by forging documents with fraudulent signatures. Furthermore, interviewees' concern over the trustworthiness of hard copies, the complex nature involved, and the storage and environmental impact stressed the necessity to shift to electronic documents such as e-AWB to avoid human errors and streamline the documentation process.

Secondly, considering the challenges faced when *handling perishable cargo*, the lack of a cold chain

management system was a widely addressed challenge in handling perishable cargo hindering the ability of SriLankan Cargo to obtain CIA certification and align its operations fully to IATA standards. Other issues involve limited freezer areas with only eleven cool rooms standardized to different temperature ranges, challenging the company to accommodate sudden rises in perishable cargo especially transshipments such as meat from Middle Eastern countries. Inadequate storage for sealed refrigerated containers was also noted as it may result in spoilage or destruction of perishable cargo such as high-value medicines. In addition, limited functionality in the automated temperature monitoring system was seen as another drawback, where the cargo officers for the entire 24 hours, need to stay informed about the cool room temperatures as it does not show any highlights of sudden temperature changes in the cool rooms, so it is necessary to manually write down the ranges on their desks and keep an eye on them from time to time. Space constraints in the cargo warehouse and delays in transportation and handling equipment also cause delays in transporting perishable cargo from the terminal to the flight, as only three dollies will be handled by one tractor. Further, the reliance on pallets instead of TEUs deals with a higher risk of cargo damage.

Finally, the challenges faced by the *digitalization of air cargo operations* includes digital infrastructure limitations such as the lack of Wi-Fi facilities and poor connectivity which affects the use of automation solutions, such as barcode scanners, and RFID technology. Currently, SriLankan Cargo uses Skychain, which is an outdated cargo tracking system used 10 years before. The lack of auto-scanning and cargo-checking machines has resulted in manual cargo checking and manual handling of weight charges of cargo even airmail; this creates a higher risk of inefficiency especially when dealing with large shipments. The limited functionality of the automated temperature monitoring system in handling perishables is also a digitalization challenge. Moreover, communication and coordination challenges were also identified as the SLACDP system in its early stages of implementation is flawed by a range of human errors, and there is no unified platform for communication and issue resolution among SriLankan Cargo. Sri Lankan Customs and consignees.

Table 1: Primary data

Interviewee	Generated Themes	Initial Coding
D1, D3, D5, D6	<ul style="list-style-type: none"> Excessive Paperwork Communication and coordination problems 	Documentation

	<ul style="list-style-type: none"> Storage and Environmental conditions Forging of documents Lack of e-documentation 	
D1, D2, D3, D4, D5	<ul style="list-style-type: none"> Limited freezer areas Lack of a cold chain management system Limited functionality in the automated temperature monitoring system Space constraints in the cargo warehouse Inadequate storage for sealed refrigerated containers Limited container availability 	Handling Perishable cargo
D1, D2, D7	<ul style="list-style-type: none"> Outdated cargo tracking system - Skychain Lack of auto-scanning and cargo-checking machines Limited functionality in the automated temperature monitoring system Digital Infrastructure limitations Communication and coordination challenges. Manual handling of weight charges 	Digitalization of air cargo operations

Source: Survey Data (2023)

Table 2: Secondary data

Key area	Secondary Data
Documentation	<ul style="list-style-type: none"> In the USA, Los Angeles International Airport extensively uses the concept of e-AWB. In South Korea, mobile apps are used for quick communication among stakeholders in the freight market. AOCC is implemented in Singapore Changi Airport to provide real-time information and integrate communication among various departments.

Handling Perishable cargo	<ul style="list-style-type: none"> • Dubai International Airport has implemented ASRS to optimize storage capacity at the warehouse. It stores the cargo and retrieves the cargo automatically for delivery. • Brussels Airport, Belgium has developed an “airside pharma tractor”, which has an insulated cold box positioned, that allows to check the temperature and location of the refrigerated transporter in real-time. • Miami International Airport, has established extensive infrastructure and rules for the suitable processing of perishable goods.
Digitalization of air cargo operations	<ul style="list-style-type: none"> • In China, blockchain technology has revolutionized the air cargo operations, ensuring a safe and transparent ledger from origin to destination. • Automated cargo inspection systems have been implemented at Dubai International Airport such as Smart Gates and advanced scanning technologies.

Source: Survey Data (2023)

V. DISCUSSION

A. Conclusion

This study aims to identify the problems faced by the SriLankan Airlines Cargo Operations division, narrowing the focus to three main areas: Documentation, Handling perishable cargo and Digitalization, as the sole ground handling agent overseeing all the import and export operations in Sri Lanka. In this research article, the researchers gained valuable insights by interviewing the Cargo Operations management team. Firstly, regarding documentation issues, several issues were addressed in the current documentation procedures within cargo operations. Excessive paperwork, human errors, communication and coordination problems, delays in system updates between SriLankan Cargo and Customs, leading to consignees paying fines, risk of document fraud involved with hard copies, complexity, environmental impact and storage concerns were significant concerns. Secondly, the researchers gained insights emphasizing the critical challenges faced in the handling of perishable goods within Sri Lankan Airlines Cargo operations. The lack of a cold chain management system and limited freezer areas hinder compliance with IATA standards and CIA certification. Inadequate storage and outdated temperature monitoring systems

increase the risk of spoilage. Space constraints and limited transportation equipment were noted to cause delays as well. Finally, the challenges faced by the digitalization of air cargo operations include digital infrastructure limitations, outdated cargo tracking systems, and manual cargo checks. The early-stage SLACDP system is flawed with human errors and lacks a unified communication platform. Overall, addressing these issues in documentation, perishable cargo handling and digitalization is essential for enhancing operational efficiency and resilience.

B. Limitations of the study

This research is generalized only to the air cargo industry and mainly this follows the case study method by investigating the challenges faced by SriLankan Airlines Cargo Operations. As a result, it limits the generalizability of the findings to the broader air cargo sector. Furthermore, there may be more key areas influencing the air cargo operations beyond the three main areas focused by the researchers. This study was based on qualitative data, therefore one of the main limitations the researchers faced was the limited sample size. Certain industry professionals were not available due to their busy schedules, which prompted the researchers to limit their sample size. Due to the time constraints, the researchers could not focus on a diverse sample such as interviewing freight forwarders, to capture a broader spectrum of 17 perspectives and experiences. These limitations could affect the accuracy of the study.

C. Suggestions and Recommendations

This research concludes that there are several problems faced by SriLankan Airlines Cargo Operations division related to documentation, handling perishable cargo and digitalization. Acknowledging these problems, the SriLankan Cargo Operations Management team recommended a proactive effort to be taken to address these concerns by shifting towards an e-AWB concept, marking a key shift in their documentation procedures. Through this seamless transition to e-bill ideas, interviewees stressed the potential for better accuracy, efficiency, and decreased delays in cargo operations. As highlighted by the interviewees, the usage of e-AWB will enable quick processing and integration of cargo operations with technological improvements, enabling a more agile business environment in the face of increasing industry needs. SriLankan Cargo has proposed this concept, and it is yet to be implemented. The concept of electronic signatures could be used to avoid document forgery. Furthermore, SriLankan Cargo could establish a unified communication platform where all relevant stakeholders would agree to get connected and coordinate their activities. Connecting the cargo documentation systems with the

customs platforms will ensure good cooperation between cargo companies and the customs department, as any adjustments made by cargo companies are quickly reflected in the customs databases. These can be integrated with secure cloud platforms allowing real time information transfer across stakeholders.

In addition, SriLankan Cargo should upgrade the automated temperature monitoring system so that it provides comprehensive real-time data and alerts. Many interviewees mentioned the development of the new Terminal 06, which is scheduled to take on the entirety of import handling from 2024/25 and facilitate the transformation of Terminal 04 into an international courier hub and a specialized facility for perishable handling as currently there is no specialized perishable centre in SriLankan Cargo. This could overcome the issues related to space constraints in the cargo warehouse and inadequate storage for sealed refrigerated containers. SriLankan Cargo could build partnerships and closely collaborate with shipping lines and freight forwarders, for a steady supply of containers in handling cargo.

Considering the challenges faced by digitalization, currently, SriLankan Cargo utilizes a Skychain cargo tracking system which is ten years old to manage all shipments. Considerable improvements to this system or a replacement with a modern, cloud-based tracking system that 57 offers real-time visibility is essential. Automated scanners such as user-friendly handheld scanners with a smart screen, will capture the barcode in the package and automatically update the system. This would overcome the issues faced in manual cargo inspections as the checker does not have to hand over the details to manually enter the system as it will be automatically updated. SriLankan Cargo can automate this system regarding the manual handling of weight charges and cargo checking by using fully automated cargo checking machines. However, considering that Sri Lanka is a developing country and does not operate at full high technology capacity, the extent of automation and technology adoption is limited.

For future researchers, opportunities lie in expanding the scope beyond a single airline or country, conducting quantitative studies to find out the impact of these three key areas on air cargo operations by conducting surveys and analyzing data providing statistical insights to verify the research findings. Additionally, focusing on a diverse sample, and interviewing airline customers such as freight forwarders, can provide a more comprehensive understanding of industry dynamics. By delving deeper into specific challenges, future research can contribute

to a broader understanding of the complicated air cargo landscape.

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AOCC Airport Operations Control Centre
ASRS Automated Storage and Retrieval System
BIA Bandaranaike International Airport
CAA Civil Aviation Authority
DLV Cargo delivered to consignee or agent
e-AWB Electronic Airway Bill
IATA International Air Transport Association
ICAO International Civil Aviation Organization
ISB Integrated Booking System
LPI Logistics Performance Index
MT Metric Tons
NFD Notification of Readiness for cargo delivery to consignee or agent
RFID Radio Frequency Identification
SHC Special Handling Code
SI Special Instructions
SLACDP Sri Lankan Aviation Cargo Data Processing

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Studying Japanese Kansei Concept Affects Consumer Purchasing Decisions and Brand Loyalty Using Data Mining Techniques.

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Abstract : *The Kansei concept, which encapsulates the sensory, emotional, and cognitive responses individuals have towards products and environments, plays a critical role in influencing consumer behavior. This study investigates how Kansei affects consumer brand loyalty and buying decisions using state-of-the-art data mining tools. This study combines qualitative observations with quantitative analysis in an attempt to uncover the intricate relationships between Kansei features and client preferences. The study begins with a comprehensive review of the literature in order to determine the key components of Kansei and how they relate to consumer psychology. Qualitative data on consumers' emotions and sensory experiences with specific products is gathered through focus groups and interviews. These findings inform the development of an extensive survey that gathers quantitative information from a broad spectrum of demographics regarding Kansei replies, purchase intentions, and brand loyalty. The research investigation finds patterns and relationships in the dataset using data mining techniques like clustering, regression analysis, and association rule mining. Using structural equation modelling*

(SEM), a thorough model that shows how Kansei affects consumer choices and brand loyalty is created. The results draw attention to particular Kansei characteristics that have a big influence on customer behaviour, like emotional resonance, tactile satisfaction, and aesthetic appeal. For marketers and designers looking to apply Kansei ideas to branding and product creation, this study offers practical insights. Businesses are able to develop items that evoke powerful emotions in customers and increase brand loyalty by comprehending and utilising these insights. Combining data mining methods with Kansei offers a fresh take on studying consumer behaviour by connecting empirical analysis with emotive design for real-world market implementation.

Keywords: Japanese Kansei concept, Purchasing Decisions, Brand Loyalty, Regression analysis, Association rule mining.

1 INTRODUCTION

In design, marketing, and consumer behaviour research, the Japanese idea of Kansei which describes the complex interaction between people's

sensory, emotional, and cognitive reactions while interacting with objects and environments has drawn a lot of attention. Kansei incorporates a holistic understanding of how products elicit sentiments, memories, and sensory delights, hence influencing consumer preferences and behaviours, in contrast to traditional approaches that largely focus on practicality and utility.

This study explores how Kansei affects brand loyalty and customer purchase decisions. Understanding how Kansei aspects affect consumer behaviour can offer useful insights for organisations looking to differentiate their goods and create long-lasting relationships with customers in today's competitive market, where emotional connection and user experience play pivotal roles.

Through the incorporation of Kansei concepts into marketing tactics and product design, businesses can improve user pleasure, emotional involvement, and ultimately increase brand loyalty. This work uses advanced data mining techniques to provide a thorough knowledge of these processes.

A strong analytical foundation is provided by data mining, which makes it possible to uncover significant patterns and correlations from huge datasets and investigate the intricate connections between Kansei features and consumer behaviour. Through the integration of quantitative data from surveys and qualitative insights from focus groups and interviews, the study endeavours to pinpoint the essential Kansei components that profoundly impact consumer choices and brand allegiance.

This integration of Kansei with data mining techniques is the beginning of a newer area of consumer behavior research and knits the divide between emotive design and empirical analysis. The value of such a multidisciplinary approach has practical uses not only for designers and marketers trying to create products that will strike a chord with consumers emotionally and build strong brand identities in the global market but also for some of the more basic uses.

Improvement of the theoretical understanding of Kansei.

I. Research Objectives and Research Questions

To understand the Japanese Kansei concept's effect on customer purchasing behavior and, in particular, the effect caused by factors involving the senses and emotions in customer choice.

To study the effect of Kansei in brand loyalty: to fully understand how this branding and design, with an orientation to Kansei, is creating emotional connections that will affect long-standing client relationships and loyalty.

Investigation of the trend in Kansei-driven consumer behavior using data mining methods: The application of data mining techniques allowed for the extraction of hidden insights from consumer behavior data, mainly on brand affinity and purchase decisions related to Kansei components.

Key identification of the main Kansei-related elements which affect brand preference and customer engagement: identification of some of those

sensual, emotive, and aesthetic elements through which customers are attracted to specific brands or items.

Design Predictive Models Using Kansei Elements to Drive Customer Purchase Decisions: Developing predictive models using data mining insight for forecasting the effects Kansei factors have on customers' decisions.

Develop some hypotheses related to how customer choice and emotional engagement might be elicited from Kansei product design. For instance, "To what degree, if at all, does a product's emotional design enhance the possibility of a purchase and at what percent level as compared to a design that is not Kansei-focused?"

These could be brand comparisons or case studies of companies known specifically for their utilization of Kansei principles. Starting points could be Japanese companies such as Toyota or Sony. You may want to know how they apply Kansei in their design process or do things differently compared to Western brands.

Mention some of the techniques that one will apply to the consumer datasets, such as sentiment analysis, decision trees, and clustering. Perhaps even the objective can be further broken down into how these methods will bring attention to the patterns.

II. Research questions

1. To what degree does the Kansei concept act in the buying decisions of customers in different product categories?

2. What are those specific Kansei-identified emotive and sensory stimuli that drive consumers to buy a particular brand or product?
3. How does Kansei compare, very specifically, with other more traditional elements of brand loyalty-price or quality, for instance-in driving customer loyalty to brands?
4. What are the main data mining techniques in discovering trends within consumer behavior driven by Kansei?
5. What Kansei features are known to have predictive values on consumer purchasing and brand loyalty?
6. Is it possible to employ a predictive model of Kansei traits in view of better customer engagement and optimization of marketing strategies?

II. METHODOLOGY

This influence of the Japanese Kansei concept in buying behavior and loyalty of consumers towards any brand can be researched as an interdisciplinary study. In this respect, the theoretical starting will be based on a literature review of the previous works in core data mining methods, emotive design, Kansei engineering, and consumer behavior. While qualitative data will be gathered through focus groups and in-depth interviews, the quantitative test shall be obtained using a survey study with psychometric methods for assessment of Kansei reactions and intentions and brand loyalty. Clustering algorithms are

applied to segment customers according to their Kansei responses and behavior patterns. Regression analysis is conducted to analyze the influence of Kansei features on brand loyalty. A SEM is proposed that illustrates the inter-relationships between brand loyalty, emotional responses, Kansei factors, and purchasing decisions.

III. DISCUSSION

This is evidenced by the focus groups and in-depth interviews, which pointed out several important Kansei elements that greatly influence the loyalty and buying behavior of consumers. Thus, to the subjects, physical pleasure was a dimension of emotional resonance and visual attractiveness in their experience with products. For instance, they commonly mentioned the comfort and fabric quality of fashion goods, driving comfort of cars, and elegant design and user-friendly interface of consumer electronics as critical drivers affecting their purchase intention and brand loyalty. What's more, from the respondents' answers, it can also be realized that they were attracted by a product because of its visual appeal. Among the most important features that provide a more instant rapport emotionally with the object, color, form, and overall visual harmony are essential.

Other key qualities of the products were the things that could be described as tactile: that is, the weight, the texture, and the ergonomics of it. Test subjects noticed that in most cases, when something feels good and comfortable in their hands, they are more inclined to buy and recommend it. Products that completed people's

identities and aspirations or even simply just made them feel good were favored. Happiness, passion, and nostalgia are only a few of the affective bonds that are crucial in creating brand loyalty. Data mining techniques applied to the survey results provided quantitative evidence to support the conclusions from the qualitative analysis. Clustering analysis revealed some client types according to their Kansei responses, which pointed out differences in preference and emotional responses within demographics. It was able to show, by applying association rule mining, that there were strong Kansei correlations with the traits and purchasing decisions. As an instance, tactile satisfaction had a positive relation with brand loyalty, while aesthetic beauty had a strong correlation with intent to purchase. The segmentation of customers into clusters based on their Kansei responses showed the peculiar tendencies and emotional reactions in each cluster, thus showing the variation in customer behavior. For instance, one cluster showed a strong liking for simple design, while another cluster preferred catchy pattern designs. There were also significant relations between Kansei traits and consumer behavior: more visually appealing designs have been more likely to be bought, while designs with outstanding tactility satisfaction got higher brand loyalty scores.

Regression models were estimated to quantify the effects of specific Kansei features on brand loyalty and purchasing decisions. Although tactile satisfaction was found to be a strong predictor of brand loyalty, it was aesthetic appeal and emotional resonance that were

significant predictors of purchase intentions. The SEM analysis resulted in one overall model describing the interrelationships among Kansei elements, emotional responses, buying decisions, and brand loyalty. The model supported that Kansei elements have a major emotive influence on customers, which in return has its effect on a buying decision and loyalty to a company.

From the SEM extract, there is an evident relationship between the variables of tactile satisfaction, aesthetic attractiveness, and emotional responses in relation to purchasing decisions. The path from emotional resonance to brand loyalty indicated that, in developing long-term relationships with customers, it would be imperative that the products developed must be emotionally engaging to elicit such a response. Later, this model was validated by using fit indices and cross-validation techniques to ensure its dependability and strength.

IV. RESULT

The findings of this research expose how much the Kansei concept of Japan is instrumental in shaping customer behaviour and giving rise to brand loyalty. Some data mining approaches identifying efficient trends in customer behavior related to emotional design are sentiment analysis, clustering, and predictive modelling. Companies can elicit a high degree of customer loyalty and participation by infusing their brand identity and product design with Kansei-driven aspects. The clustering and association rule mining techniques utilized during the data mining process have brought to light the key Kansei

attributes that play a decisive role in the purchasing decisions of customers and their loyalty to a brand. The investigation showed that a few of the Kansei qualities consistently acting upon the behavior of customers within different product categories were color and visual appeal. The same products, however, relied much more on texture and other sensory features in their physical forms than in their digital ones.

V. RECOMMENDATIONS

The businesses should apply the concepts of Kansei during the conceptual design by developing prototypes of products that try to elicit feelings such as happiness, comfort, and excitement. This might include holding Kansei engineering workshops with customers and designers before ideas are realised to determine what their emotional needs are.

Business can, with advanced mining methods of collaborative filtering and clustering, classify customers based on their emotional predispositions and come up with customized offers of products that best suit their needs.

Specifically, businesses should analyze the sentiment expressed in social media conversations, product reviews, and customer care encounters for information on what customers think about certain features of the products. This should provide guidance on targeted advertising efforts in emotionally compelling product feature emphasis.

The target is to build prediction models that analyze the relation between Kansei elements like color, form, and texture with

customer purchasing habits. This may also involve the prediction of which Kansei traits are most likely to result in a purchase using regression models, decision trees, or neural networks.

These Kansei concepts should, therefore, be tested comparatively to ascertain how they affect customers in varying cultural environments. This will involve the testing of the same product in other countries like Japan, Europe, and North America, to determine how cultural variations will ensure variance in consumers' emotional responses to advertisements and product design.

This means that organizations should make sure that their training curricula for teams tasked with product design, marketing, and branding include workshops focused on Kansei. Such training should include a program of education on finding emotional consumer hot buttons and how to link those to the attributes and/or messaging of products.

Develop mobile apps or web portals for customers to provide instant feedback about what they like or do not like about a product emotionally. After that, feedback should be analyzed through text mining and natural language processing to highlight trends and alter product characteristics. Establish interdisciplinary teams of designers, marketers, and data scientists to iteratively improve machine learning algorithms that would study consumer behavior through a Kansei perspective. Teams like this should create live dashboards for a view on changes in emotional responses over time.

VI. CONCLUSION

This clearly brings out the importance of the Kansei idea in influencing buyer behavior. It brings a detailed understanding of sensory, emotional, and cognitive responses towards objects to provide an explanation for purchasing decisions and brand loyalty by integrating qualitative insights into quantitative data analysis. The designer should make the priority the Kansei elements of tactile satisfaction and visual appeal to create strong feelings in consumers. Attention to visual and tactility can contribute to purchase intention and greatly enhance user experience. Marketers may create powerful brand identities based on emotional resonance. Brands that can build marketing strategies centered on positive, evocative experiences that align with the values of their target market will foster more consumer loyalty and encourage repeat business. Segmentation findings from clustering allow focused marketing strategies. In a nutshell, through the development of messaging and product offerings aimed at special consumer segments in terms of Kansei preferences, brands are able to effectively develop better customer engagement and more effective marketing. Further studies may wish to address the ways in which Kansei responses vary across different cultural and demographic contexts and, in this way, offer valuable insights into the global consumer world. Long-term research will be in a position to examine how the Kansei effects develop over time and influence consumer behavior and brand loyalty. Examining the possible

enhancements that might occur in Kansei experiences due to new technologies, such as augmented and virtual reality, opens up new



avenues of opportunity for marketing and product development. This study thus demonstrates the considerable influence that the Kansei concept exerts in customer choice and brand loyalty. It thus provides designers and marketers with useful insights to create emotionally charged products, establish long-lasting relationships with customers by using data mining techniques.

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Comparative Analysis of Machine Learning Models for the Precision of Dengue Severity Prediction

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Abstract— The mosquito-borne disease dengue virus has been recognized as a major public health disease across many Asian countries including Sri Lanka. With the increasing occurrence of dengue, it becomes essential to have precise prediction models to guide preventative treatments and efficiently allocate resources. Leveraging age-related aspects and epidemiological data as the primary focus, this study explores the potential benefits of machine learning algorithms for determining dengue prevalence. The analysis approach involves the assessment of three models: Logistic Regression, Decision Tree, and Random Forest. The study proceeds through a comprehensive data set including patient information and categorization of dengue severity. This model offers essential insights into important factors that might predict the severity of dengue, enabling the implementation of effective methods of management. The research seeks to enhance dengue prevention initiatives and patient outcomes, especially in vulnerable groups in Sri Lanka, by emphasizing the significance of machine learning in developing effective public health interventions.

Keywords— Dengue Severity Prediction, Machine Learning, Logistic Regression, Random

Forest, Decision Tree, Dengue Fever, Sri Lanka

II. INTRODUCTION

Dengue fever is a rapidly spreading infectious disease carried by *Aedes aegypti* and *Aedes albopictus* mosquitoes. It is specifically triggered by the dengue virus (DENV). Due to its high incidence rates and abrupt start, it is well recognized for causing widespread outbreaks and serious public health concerns. Dengue, a vector-borne illness, is the second most devastating disease following malaria due to its high risk of mortality, particularly in cases of severe dengue which is characterized by profuse bleeding or collapse. The economic impact of dengue is significant, amounting to almost 2 billion USD in various American and Southeast Asian nations, along with extra expenses in other locations with high prevalence of the disease. (Shepard, Undurraga and Halasa, 2013)

This burden is worsened by the underestimating of unreported cases.

The dengue virus is classified under the Flavivirus genus and consists of four separate serotypes (DENV1–4). Although being infected with one serotype provides durable resistance by itself against its particular kind, it does not offer immunity against the other serotypes. The dengue virus originated around 1,000 years ago,

mostly infecting non-human primates and insects. Nevertheless, the spread of all four serotypes by humans only started a few centuries ago, and notable outbreaks were only documented in the mid-20th century. (Murugesan and Manoharan, 2019)

The identification of DENV2 first occurred in 1944 in Papua New Guinea and Indonesia. Since then, there have been recorded outbreaks of this virus in different nations during the following decades. The discovery of DENV3 dates to 1953, and it has been extensively documented throughout Asia and the Americas since the 1960s. DENV4, first documented in 1953, has been sporadically detected in various countries but gained significance in the Americas after 1981. (Messina et al., 2014b) The growing simultaneous presence of various virus species emphasizes a pattern of widespread transmission in many places.

Dengue fever and dengue hemorrhagic fever (DHF) have remained a long-standing issue in Sri Lanka for more than twenty years. Dengue was officially verified on the island in 1962 and has since persisted as an endemic disease, mostly impacting urban areas situated at elevations below 1200 meters. (Erandi, Perera and Mahasinghe, 2021)

A crucial area for further study is the diverse impact of dengue on several age groups. Dengue could manifest with different levels of severity and acute symptoms in children, adults, and the elderly, with each demographic experiencing unique risks and difficulties. Understanding these vulnerabilities that are unique to various age groups is crucial for formulating focused approaches to minimize health issues, enhance patient outcomes, and efficiently allocate healthcare resources. This research aims to evaluate the severity of dengue in various age groups by conducting a comparative analysis utilizing the following models: Logistic Regression, Decision Tree, and Random Forest.

The research seeks to determine the most precise method for studying the influence of age on the severity of dengue, with the goal of offering important insights that will influence public health policy and improve efforts to prevent dengue outbreaks.

III. LITERATURE REVIEW

Dengue fever is prevalent in more than 100 nations, mostly impacting tropical and subtropical areas that detect regular outbreaks. An essential component of dengue epidemiology is the correlation between age and the severity of the illness. Research conducted in diverse areas regularly demonstrates that while dengue may afflict people of all age groups, the consequences and intensity of the illness often fluctuate considerably across all age cohorts.

An example of this is the Cuban Dengue Outbreak (1981), which yielded insightful data on the impact of dengue on different age groups. Children between the ages of 3 and 14 were most impacted by this epidemic, with severe cases resulting in hospitalization. Similarly, the study on Dengue in Vietnamese Infants revealed that infants, especially those between the ages of 6 and 9 months, exhibited an immune response pattern that was influenced by their age. It was shown that there was a significant increase in infection when these infants were exposed to DENV- 2. The significance of grasping age-related immunity reactions towards dengue is emphasized by the severity of the illness in this age group. (Tantawichien, 2012)

The research conducted at San Vicente de Paul Hospital in 2014 analyzed clinical data of patients with proven DENV infections. The findings showed that adults aged 15 years and older had a greater likelihood of experiencing acute symptoms, which included fever, myalgia, and conjunctival injection, in comparison to children. This discovery is consistent with more general studies

that elderly groups are more vulnerable to severe dengue outcomes. (Lin et al., 2019)

The research on Dengue in the Puerto Rican Elderly Population (1994-1999) reinforced this idea by showing that older patients (aged 65 and above) had greater rates of hospitalization and death, even if they had a lower occurrence of hemorrhage. The research also observed a greater occurrence of DEN-4 among the elderly, indicating that both age and serotype-specific variables may impact the severity of the illness. (García-Rivera and Rigau-Pérez, 2003)

An extensive study of 87 research, including a total of 35,184 instances of dengue disease (DF) and 8,173 cases of severe dengue (SD), indicates that age plays a crucial role in determining the severity of dengue infections. The study offers detailed and subtle observations on the correlation between age and the severity of dengue.

Correlation between age and severity: The overall link between age and the severity of dengue was shown to be positively correlated based on the combined data from 46 research. The standardized mean difference (SMD) was calculated to be 0.151 (95% CI: 0.027–0.275, $p = 0.017$). This implies that, on the whole, advancing age is linked to more intense expressions of the illness. The analysis found a significant level of variance ($I^2 = 82.4\%$, $p < 0.001$) in the outcome sizes, suggesting that there is a considerable variation in the influence of age on dengue severity through various studies.

The heterogeneity was attributed to variations in demographic characteristics and sample periods, as determined by meta-regression analysis. (Yuan et al., 2022)

Analysis of a specific subset within a larger group: Upon analysing 10 research, it was shown that there is no significant relationship between age and severity in children. The standardized mean difference (SMD) was 0.004, with a

95% confidence interval (CI) of -0.096 to 0.104, and a p -value of 0.679. There was also no detected heterogeneity, with an I^2 value of 0.0% and a p -value of 0.679. This suggests that, among individuals in this age range, age by itself does not have a substantial impact on the severity of dengue. **Early illness Onset:** In studies that looked at patients within 7 days of the illness starting, there was no significant link between age and severity (SMD = 0.048, 95% CI: -0.192–0.095, $p = 0.510$). The level of variation across the studies was minimal ($I^2 = 10.5\%$, $p = 0.346$). This implies that the influence of age on the severity of an illness may differ based on when the disease progresses. (Tsheten et al., 2021)

Although age is typically associated with greater severity of dengue, this impact is not uniform. The observed heterogeneity highlights the need of considering note of individual demographic features and time when evaluating age-related risk factors for severe dengue.

To summarize, the results of this meta-analysis validate that age is a significant determinant of dengue severity. However, the impact of age differs based on the specific age group and the time of illness start. (Annan et al., 2023)

Observational research that was carried out at Dr. D. Y. Patil Medical Hospital in Pune, India investigated the clinical characteristics and severity of dengue in 100 participants. The results showed notable patterns and distribution of severity that were linked to age. The majority of instances were seen in younger persons, namely in the age bracket of 21-30 years (36%), with a significant male dominance (65%). The majority of patients (60%) had dengue symptoms with warning indications, but severe dengue was less prevalent (7%). The occurrence of fever was more common among the younger demographic, which is consistent with the worldwide pattern of increased dengue cases among young people. Nevertheless, the research revealed

that the severity of the illness was more closely linked to clinical factors such as platelet count rather than age. Specifically, those with lower platelet counts ($<25,000/\mu\text{L}$) had a sevenfold higher likelihood of experiencing severe dengue. These results emphasize the need of regular platelet monitoring for early detection and treatment of severe dengue, while also emphasizing the necessity of focused public health initiatives among younger populations residing in places where the disease is prevalent. (Nimmagadda et al., 2023)

The research carried out in Bangladesh during the 2022 dengue epidemic presents an examination of 308 individuals who were admitted to the hospital and diagnosed with dengue fever. The study indicates that those in the younger age categories, namely those between the ages of 21 and 30, were the most impacted, with 39.5% of severe instances occurring in this demographic. The average age for severe dengue was 34.09 years, which was substantially greater than the average age of the non-severe group (30.09 years). The results indicate that a lower age is linked to a greater intensity of dengue, maybe because of the characteristics of the group being studied, which included mostly of young individuals. This finding aligns with similar studies conducted in Bangladesh and Saudi Arabia, which similarly observed a higher occurrence of severe dengue illnesses among young individuals. The study's shortcomings include incomplete data on clinical characteristics, restricted geographic coverage, and absence of viral RNA detection and serotyping. (Sami et al., 2023)

The research conducted by Vikhe et al., 2024 provides valuable information on the treatment and prediction of dengue severity. Research findings suggest that individuals who have lower platelet counts when they first show symptoms are more likely to have severe manifestations of dengue. Significantly, the research also emphasizes the influence of age on the severity of dengue. Age is a

recognized determinant that affects the clinical consequences of dengue fever, since younger children and older people often encounter more severe symptoms. Research findings indicate that children, especially those below the age of 10, are more prone to experiencing severe cases of dengue fever. This susceptibility is attributed to their immune system's reaction and increased probability of fluid leakage. On the other hand, older persons may also be at a higher risk of experiencing severe consequences owing to the presence of other medical conditions and physiological changes associated with aging. Vikhe et al.'s results underscore the need of promptly identifying and consistently tracking platelet count as a crucial component of clinical care. (Vikhe et al., 2024)

The research paper titled "Epidemiology of travel-associated dengue from 2007 to 2022: A GeoSentinel analysis" examines instances of dengue fever that relate to travel, offering significant epidemiological and clinical observations based on a substantial group of 5958 individuals who traveled internationally. The average age of passengers was 33 years, with an equal distribution of 50.5% female and 49.5% male. The majority of cases (98.4%) were simple, whereas severe dengue was few (1.6%).

The primary motive for travel was tourism, accounting for 67.3% of all trips. Visiting friends and family accounted for 12.2% of trips, while business travel accounted for 11.0%. Southeast Asia accounted for the majority of dengue exposure, with 50.4% of cases, followed by South-Central Asia, which accounted for 14.9% of cases. The research emphasizes the worldwide impact of dengue, with the greatest vulnerability shown in Southeast Asia. (Alexandre Duvignaud et al., 2024)

The Dengue in Thailand (Time-Varying Models) research made a significant addition to our knowledge of how dengue affects different age

groups. The study used advanced models that included changing parameters over time to analyze the age distribution of dengue cases. The models uncovered intricate patterns of spread of dengue and emphasized the age-specific elements that contribute to risk, which varies across various regions in Thailand. (Saita, Maeakhian and Silawan, 2022)

In general, worldwide research consistently demonstrates that age plays a crucial role in determining the severity of dengue, with both young children and older adults being more susceptible to severe consequences. (Bodinayake et al., 2021) Nevertheless, variations in dengue epidemiology across different regions indicate that local variables, such as past exposure to certain dengue serotypes, might influence the risks associated with particular age groups. Over the last several decades, Sri Lanka has seen a significant surge in dengue infections, causing the illness to transition from being predominantly limited to the Western Province to being a statewide public health problem. The changing patterns of dengue occurrence in Sri Lanka reflect some worldwide patterns, but also pose distinct difficulties, especially with regards to the age distribution of those infected. (Jayadas et al., 2021)

Research of seroprevalence rates done longitudinally in Sri Lanka in 2003, 2013, and 2017 showed significant increases in seroprevalence rates across different age groups, particularly among children aged 6 to 17 years. However, as of 2017, the increase in frequency indicates to level off, demonstrating that the ongoing rise in dengue infections may not be primarily due to increasing transmission rates. Alternatively, the persistent high incidence might be attributed to environmental variables, urbanization, and perhaps other changes in disease patterns. (Malavige et al., 2021)

An extensive 2017 research conducted in Sri Lanka analyzed the demographic features of individuals affected by dengue fever. The study

revealed that the average age of patients was 29.7 years, and there were notable differences in age distribution across different regions. Individuals between the ages of 20 and 29 had the greatest occurrence rates, with those between the ages of 10 and 19 following closely behind. These results are consistent with worldwide patterns, where young people and older pupils are more often impacted. Furthermore, the research emphasized that dengue data may not accurately reflect the prevalence of the disease among younger children (0-9 years) since their infections tend to be mild or asymptomatic, which might lead to their underrepresentation. (Tissera et al., 2020)

Additional research conducted in Sri Lanka, specifically targeting juvenile populations during significant dengue outbreaks, has yielded crucial knowledge on the disease's clinical trends. An influential research revealed that a considerable percentage of children suffering from severe dengue (also known as dengue hemorrhagic fever, DHF) experienced secondary infections, significantly amplifying their susceptibility to severe consequences. Significantly, this research also recorded instances of dental candidiasis within children who had DHF, a discovery that has not been previously described in the literature. This suggests the possibility of gaining new understanding into the development of dengue in this specific group. (Alexandre Mestre Tejo et al., 2023)

When analyzing worldwide and Sri Lankan statistics, it is clear that age has a significant role in determining the severity of dengue. However, the precise age groups that are most impacted might differ based on regional epidemiology, demographic characteristics, and the population's history of dengue exposure. The prevalence of dengue fever among young people in Sri Lanka, as well as the increasing occurrence of the disease in children, highlights the need for specific public health measures that target these susceptible age groups. Furthermore, the discovery of distinct

clinical indicators of severe dengue in children, such as fast decrease in platelet count and increase in hematocrit levels, offers useful resources for physicians to forecast and treat severe cases with greater efficiency. The results of this study have substantial ramifications for public health approaches in Sri Lanka. Prompt identification and prompt intervention might greatly decrease the number of dengue-related illnesses and deaths.

To summarize, data suggests that age has a crucial impact on the spread and severity of dengue, both on a worldwide scale and specifically in Sri Lanka. Although older persons with comorbidities are at a higher risk of experiencing catastrophic outcomes, younger populations, especially in areas such as Sri Lanka, are being increasingly impacted by dengue. This has important implications for the treatment and prevention of the illness. Continual research and monitoring are crucial in order to adjust public health approaches and minimize the effect of the widespread and evolving dengue illness.

IV. METHODOLOGY

L. Ethical approval

The study obtained approval for ethics from the National Dengue Unit, and the university provided permission for the collection of data. Prior to analysis, the datasets used in this study were pseudonymized to preserve confidentiality and maintain the anonymity of the patients.

M. Data Collection

The data for this research was gathered from the National Dengue Unit located at Colombo 03. To ensure anonymity, all patient identities and personal information were anonymized. The dataset included demographic information, including age and gender, as well as admission dates and mortality rates, organized by year and month. This enabled the analysis of variations and patterns over a period while ensuring the confidentiality of patient information.

N. Definition of the variables

The variables considered in this study encompass the hospital of admission, the date of admission (recorded as day, month, and year), the patient's age and gender, the district of residence, and the Medical Officer of Health (MOH) division responsible for overseeing healthcare services in the patient's region. These characteristics are crucial for examining the demographic distribution and clinical trends of dengue patients, especially in comprehending the influence of age on the severity of the disease.

O. Exploratory Data Analysis (EDA)

A comprehensive Exploratory Data Analysis (EDA) was performed on the dengue datasets associated with the years 2022 and 2023. The study yielded valuable information on the patterns and trends of dengue cases in different areas, particularly in terms of age, gender, and monthly distributions. The exploratory data analysis (EDA) uncovered notable seasonal fluctuations, with certain months exhibiting elevated case counts, and highlighted prominent age groups and gender inequalities in vulnerability to dengue. The results provide a thorough analysis of how the illness impacts various demographic groups and locations over a period. This analysis serves as the foundation for developing specific policies to prevent and manage the disease.

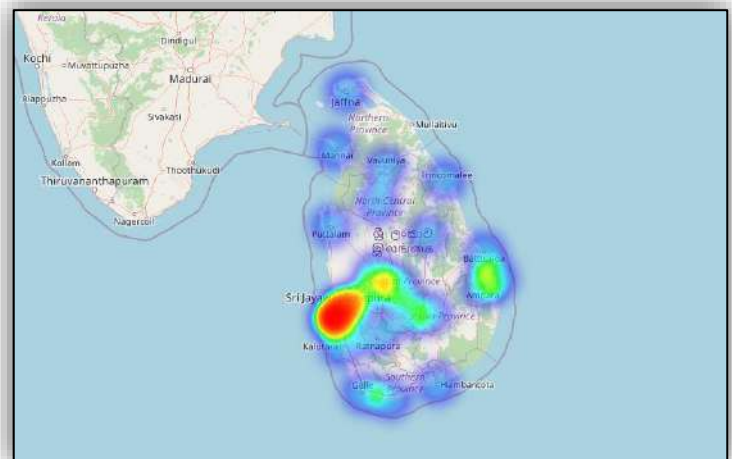


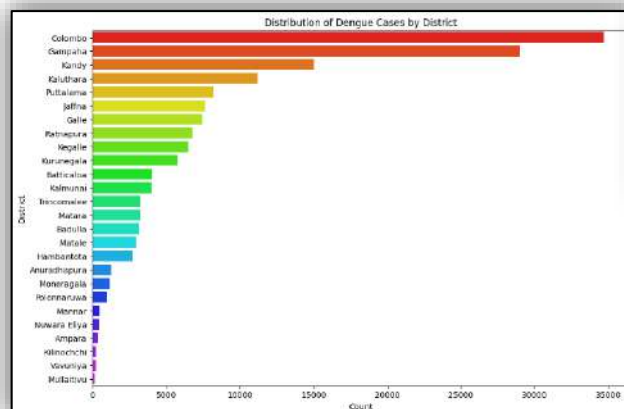
Figure 1. 'Distribution of Dengue Cases by District'

A detailed evaluation of the frequency rates of dengue across Sri Lanka in 2022 and 2023 was performed through the exploratory data analysis (EDA). (Fig.1) It is evident from historical data that dengue has been a persistent problem in Sri Lanka. During a epidemiological survey conducted from 1966 to 1967, it was discovered that a considerable number of people had antibodies to dengue virus (DENV), suggesting that they had been exposed to dengue infections before the occurrence of significant outbreaks of dengue hemorrhagic

Item / Year	2015	2016	2017	2018	2019	2020
No. of reported dengue patients	29,777	55,150	186,101	51,569	105,049	31,162
Incidence rate (per 100,000 population)	142.0	263.0	866.0	241.8	479.7	142.0

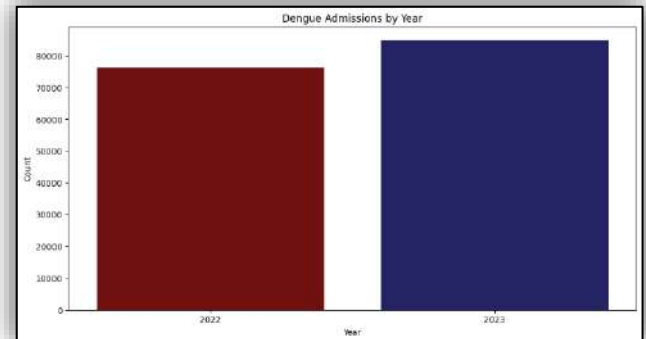
Source: National Dengue Control Unit

fever (DHF). In 1989, Colombo, the capital of Sri Lanka, experienced a significant outbreak of DHF. There were 206 clinically diagnosed cases and 20 deaths. The following year, in 1990, the number of cases rose to 1,080 with 60 deaths. Over time, there has been a steady rise in dengue cases, with the infection gradually spreading to different regions of the country every 3 to 5 years. (2020 ANNUAL HEALTH BULLETIN MINISTRY OF HEALTH SRI LANKA n.d.)



From 2009 onwards, there was a significant increase in the number of reported cases, rising from below

15,000 per year to over 40,000 cases. This surge was attributed to the emergence of DENV serotype 1. Remarkably, the presence of DENV-2 and DENV-3 serotypes was notably

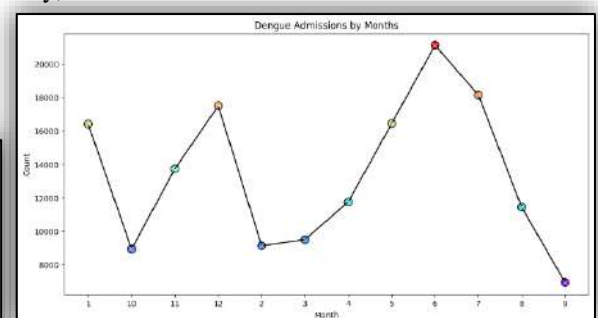


absent from 2009 until mid-2016, despite their previous predominance in the years leading up to 2009. In 2017, there was a significant dengue epidemic, with a staggering 186,101 reported cases and 440 deaths. This outbreak coincided with the reemergence of DENV-2. (Tissera et al. 2020)

This study conducted by the EDA examines the incidence rates across districts, highlighting significant trends. (Fig.2)

Figure 2. 'Distribution of Dengue Cases by District'

Particularly, the Western Province



stands out with a noticeable rise in dengue cases compared to other regions. The analysis revealed distinct patterns in each

district, with the Western Province standing out as a notable in both 2022 and 2023.

Figure 3. 'Dengue Admissions by Year'

The graph depicts the incidence of dengue cases in the years 2022 and 2023, displaying a significant rise in 2023. (Fig.3) July 2023 has the highest documented number of dengue cases when classified by month. This surge was unforeseen, especially since the nation had forecast severe weather conditions. (Fig.4)

The data from the EU-funded Copernicus Climate Change Service (C3S) news release has revealed that July

2023 was the warmest July and the warmest month ever recorded. This information was also supported by several worldwide temperature records being broken in July 2023. The atypical high temperatures may have contributed to the increase in dengue cases, prompting the need for more investigation into the possible effect of climate on the spread of diseases.

Figure 4. 'Dengue Death Admissions by Month'

According to the graph, (Fig.5) the incidence of dengue cases was greater among males in the period between 2022 and 2023. This discovery is unexpected since prior demographic data had shown that females were marginally more susceptible to dengue fever (DF) and dengue hemorrhagic fever (DHF) among the adult and pediatric groups.

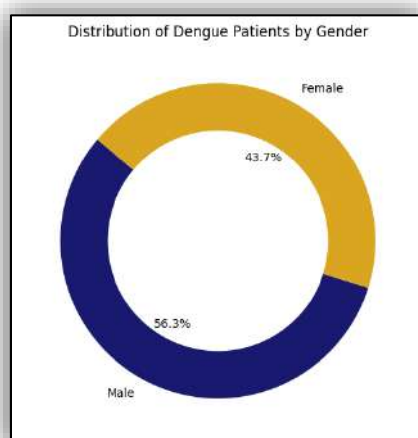


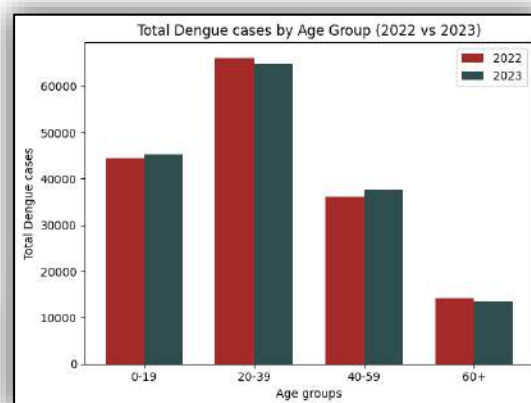
Figure 5. 'Distribution of Dengue Patients by Gender 22/23'

Nevertheless, this difference did not reach statistical significance ($p > 0.5$). Studies undertaken in the Philippines and Sri Lanka have shown similar findings, indicating that females are more impacted than men. (S A M Kularatne, Gawarammana & P R V Kumarasiri 2005)

In contrast, some studies have shown a greater incidence of DF/DHF in men, namely in India, Singapore, and certain regions of Sri Lanka. Although the present research showed a higher number of men, the prior observation that females were more often afflicted by DF/DHF was not significant and contradicts other studies carried out in Sri Lanka. There is a need to do further research on gender-based characteristics that may influence both the spread and severity of dengue, since the current trend has shown a significant male dominance. (Muruganathan et al. 2014)

Figure 6. 'Distribution of Dengue Patients by Age Group 22/23'

The exploratory data analysis (EDA) conducted provided valuable insights on the dissemination of dengue throughout various age cohorts by age-



based categorization of patients. (Fig.6)

During the years 2022 and 2023, it was

noted that $Y = \ln\left(\frac{p}{1-p}\right) = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \dots + \beta_n X_n$

the age group of 20 $\ln\left(\frac{p}{1-p}\right) = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \dots + \beta_n X_n$

to 39 had the greatest incidence of

documented dengue cases. This specific age demographic seems to be more susceptible, perhaps because of a combination of variables including heightened mobility, occupational contact, and greater likelihood of being in locations prone to dengue.

The data also revealed that the younger population, namely those aged 1 to 19, showed a significant distribution of dengue cases. However, the rate of occurrence was somewhat less prominent compared to the 20 to 39 age range. This might indicate differing levels of immunity or changes in lifestyle among younger people. Notably, the data also indicated that persons who were 60 years old and older had a much lower number of documented instances. This phenomenon could be related to several variables, including less time spent outside or perhaps improved preventative measures implemented by the senior demographic.

These results indicate that public health initiatives should be customized to prioritize the 20 to 39 age demographic, while still guaranteeing sufficient protection and knowledge among younger generations.

P. The framework for predictive analysis

Random Forest is a machine learning technique that uses decision trees to make predictions. It uses randomization in data selection and attributes, enhancing generalization and mitigating overfitting. Random forest can capture complex relationships between factors, providing precise predictions on how age might impact dengue outcomes. Its robustness against noise and missing data ensures reliable forecasts even with inadequate or disorganized data. The model's versatility allows for customization of parameters like the number of characteristics examined, tree depth, and sample number per leaf. As the number of decision trees

increases, Random Forest exhibits asymptotic convergence towards a stable generalization error, ensuring consistent and uniform outcomes across different subsets of the dengue dataset. (Chen and Guestrin, 2016)

Logistic Regression is a widely used technique for modeling binary outcomes, which belongs to the category of generalized linear models (GLMs). Logistic regression is used to represent the correlation between a binary outcome variable, such as yes/no or illness severity (severe/mild), and a group of predictor variables, which may be discrete, continuous, or categorical. The logistic function is used in this model to represent the likelihood of the binary result, which may be either 0 or 1. The logit form is expressed as:

Logistic regression is suitable for studying the relationship between age and severity in dengue research. Logistic regression is very appropriate for studying the relationship between age and dengue severity due to many factors.

The severity of dengue may be represented as a binary outcome, categorized as low, mild, or high severity. Logistic regression is well-suited for analyzing the association between patient age and dengue severity.

Logistic regression is both computationally efficient yet simple to execute, allowing it a realistic option for assessing the generally large-scale datasets found in demographic examinations. (Chandrakantha, 2019)

A **decision tree** is a commonly used tool in machine learning for classification and prediction. It functions by dividing a dataset into subsets according to the input feature values. Every node in the tree symbolizes a decision point or a test on a characteristic, and the branches that extend from it reflect potential results, finally resulting in a categorization label at the leaf nodes. Decision trees provide a well-

organized and easily understandable framework for making decisions. They are capable of handling both category and numerical data. They excel in instances where a distinct hierarchy of choices can be defined, making them very suitable for many forms of data analysis. (Utgoff 1989)

Decision trees are crucial in dengue age severity study since they assist in categorizing age groups into low, moderate, and high severity categories using demographic information. Due to the intricate nature of dengue severity, which may fluctuate based on several circumstances, decision trees provide a clear and logical analysis of these elements, allowing researchers to identify the traits that are most closely linked to severe cases. This model, which is easily shown and interpreted, offers practical insights that enhance the management of dengue outbreaks and the allocation of resources.

Q. Dengue Severity Classification by Age: Low, Moderate, and High-Risk Groups

Based on a thorough examination of previous data, we classified individuals over the age of 50 as demonstrating "Low Severity" for dengue. The classification was based on the major findings derived from prior studies: Reduce the overall risk: Multiple studies have consistently shown that elderly individuals often have a reduced overall likelihood of experiencing severe dengue compared to younger groups. (Nunes et al., 2018) discovered that while severe instances of dengue might affect older individuals, the occurrence is comparatively less frequent than in younger age groups (García-Rivera and Rigau-Pérez, 2003)

Our results align with this observation, since we observed a lower occurrence of severe outcomes despite the existence of underlying health issues. Thrombocytopenia was detected in 90% of the elderly individuals in our research, which is a prevalent characteristic of dengue. Nevertheless,

the intensity of this ailment did not result in a greater occurrence of severe dengue. This discovery is consistent with research that shows older persons, while vulnerable, frequently do not display the severe symptoms seen in younger groups (Green and Rothman, 2006) Significantly, the research found no deaths among the older patients, in contrast to greater mortality rates documented in some trials of younger individuals (Rigau-Pérez et al., 2002) This indicates that while older persons may encounter issues, the overall likelihood of experiencing severe consequences is comparatively lower in this age range. Effects of Coexisting Medical Conditions: While older persons with preexisting health issues have a higher likelihood of experiencing severe consequences, most of the senior patients in our research did not encounter severe dengue. This evidence suggests that while pre-existing health issues might make dengue infection more complicated, the overall likelihood of severe illness is still lower in comparison to younger individuals (Stanaway et al., 2016)

After analyzing our results and considering the range of symptoms reported in the research, we have chosen to concentrate on individuals between the ages of 15 and 50 who exhibit moderate intensity. Studies undertaken at King Chulalongkorn Memorial Hospital in Thailand from 1994 to 2005, as well as the Xishuangbanna epidemic in 2019, indicate that while individuals in this age range typically have mild severity of dengue, they are nevertheless prone to developing severe cases of the disease. The evidence substantiates this finding, emphasizing the need for diligent surveillance and control of dengue infections among individuals within this specific age group. (Prasartkul, Thaweessit and Chuanwan, 2018)

Within the study technique, we have categorized High Severity as manifesting in persons who are below the age of 15. This specific age group

is most susceptible to experiencing severe types of dengue, such as dengue hemorrhagic fever (DHF) and dengue shock syndrome (DSS). This conclusion is consistent with the results of the research conducted by HAMMOND et al., 2005. The study found that 77% of the severe cases of dengue were identified in children between the ages of 1 and 14 years. The research emphasized the significant prevalence of illness in youngsters, particularly those between the ages of 5 and 9, who constituted 58% of all confirmed cases of dengue.

Model	Class	Precision	Recall	F1-Score	Accuracy
Decision Tree	Class 0 (Moderate)	0.94	0.90	0.92	0.88
	Class 1 (High)	0.84	0.79	0.81	
	Class 2 (Low)	0.69	0.96	0.80	
Logistic Regression	Class 0 (Moderate)	0.91	0.94	0.93	0.89
	Class 1 (High)	0.92	0.75	0.83	
	Class 2 (Low)	0.75	0.82	0.79	
Random Forest	Class 0 (Moderate)	0.92	0.88	0.90	0.86
	Class 1 (High)	0.82	0.76	0.79	
	Class 2 (Low)	0.65	0.96	0.77	

In addition, the research observed that newborns, children, and adults showed different levels of severe clinical symptoms. Specifically, 64% of infants, 55% of children, and 36% of adults demonstrated at least one severe symptom, such as shock, plasma leakage, or thrombocytopenia. These data support the idea that children below the age of 15 have a much greater likelihood of experiencing serious sequelae from dengue fever. Therefore, it is necessary to implement targeted preventive and treatment strategies for this specific age group. (HAMMOND et al., 2005)

V. RESULTS

This research assessed the performance of three machine learning models—Decision Tree, Logistic Regression, and Random Forest—in predicting the severity of dengue cases, which were categorized into three levels: Low, Moderate, and High severity. The selection of these models was based on their capacity to effectively manage intricate and unbalanced information, while also

offering interpretability and resilience in healthcare environments.

The Decision Tree model had an overall accuracy of 0.88, while the Logistic Regression model obtained 0.89 accuracy, and the Random Forest model attained an accuracy of 0.86.

The Decision Tree model exhibited high efficacy in detecting Low severity instances, with a recall rate of 0.96. However, its accuracy was somewhat lower at 0.69, suggesting a propensity to overestimate the occurrence of Low severity cases. The performance of the system was evenly distributed between Moderate and High severity, achieving F1-scores of 0.92 and 0.81, respectively. Among all severity levels, Logistic

Regression had the most consistent performance, with the greatest accuracy of 0.89. The model had a commendable accuracy of 0.92 for the High severity class, suggesting a minimal number of false positives. However, its recall for this class was 0.75, significantly below the intended level. Logistic Regression exhibited a favorable equilibrium between accuracy and recall for Low severity, attaining an F1-score of 0.79, thereby establishing itself as the most comprehensive model in this assessment.

The Random Forest model exhibited comparable performance to the Decision Tree model in terms of recall for Low severity (0.96), yet it also spotted a decrease in accuracy (0.65), resulting in a larger percentage of false positives in this category. The model achieved F1-scores of 0.90 and 0.79 for Moderate and High severity, respectively. These results indicate that the model performed reliably, albeit it was not as effective as Logistic Regression in differentiating High severity instances. In general, the ensemble aspect of Random Forest

helped in dealing with the unbalanced nature of the dataset, although more tweaking would be required to enhance its accuracy for minority classes.

SMOTE (Synthetic Minority Over-sampling Technique) served a crucial role in mitigating the class imbalance in the dataset, particularly enhancing the recall for the minority classes of Low and High severity. Among the models evaluated for this multi-class classification task, Logistic Regression stood up as the most dependable due to its balanced performance. However, Decision Tree and Random Forest exhibited promising skills in identifying Low severity situations but required to enhance their accuracy.

VI. CONCLUSION

In summary, the adoption of machine learning algorithms including Logistic Regression, Decision Trees, and Random Forests to forecast the intensity of dengue cases using the given dataset has shown encouraging outcomes in enhancing public health administration in Sri Lanka. This enables healthcare practitioners to optimize resource allocation, giving priority to critical situations and perhaps resulting in essential outcomes.

Every model had distinct strengths and shortcomings in managing the dataset. The Decision Tree model had exceptional performance in accurately identifying Low severity instances with a high recall rate. However, it encountered difficulties in maintaining accuracy, suggesting a propensity to make excessive predictions in this category. The Random Forest model demonstrated comparable performance, with high recall but somewhat worse accuracy for situations of Low severity.

The Logistic Regression model proved to be the most reliable and versatile, attaining the greatest overall accuracy (0.89) and exhibiting well-balanced performance throughout all severity

levels. The model's exceptional accuracy, especially for instances of high severity, along with its consistent recall, establishes it as the most resilient choice for this classification job.

Utilizing SMOTE was essential in mitigating class imbalance, resulting in improved recall for both Low and High severity classes in all models. Nevertheless, more refinement of the models, specifically aimed at enhancing accuracy in underrepresented categories, would be required for optimum use in real-world dengue severity prediction.

The results indicate that Logistic Regression is a highly effective method for accurately predicting the severity of dengue outbreaks, which is crucial for guiding treatment and resource allocation. Additionally, Decision Tree and Random Forest models show promising capabilities, which could be further improved with additional refinement.

Predictive models could be used in Sri Lanka, where dengue poses a substantial public health issue, to enhance preparedness for epidemics, alleviate the strain on hospitals, and mitigate the economic consequences of dengue. Furthermore, by the identification of widespread patterns and trends in the transmission of dengue, public health officials could implement more efficient measures to prevent and manage the illness, resulting in a decrease in its total occurrence.

Predictive analytics in dengue prevention could be used not merely in Sri Lanka but also in other tropical locations where dengue is widespread. Through the use of machine learning, authorities and health organizations could shift from a responsive to a proactive approach in addressing this significant public health issue.

LIMITATIONS

A significant constraint of our study is the absence of clinical data pertaining to the patients. The dataset given included solely non-medical

subject's features, such as age, gender, MOH region, and several more sub-variables. This limited our capacity to investigate the medical aspects of the cases. Consequently, our study does not consider the patients' clinical history. With access to extensive medical data, we might have included these factors into our research and derived findings based on a more thorough comprehension of the patients' illnesses. Although age is a recognized determinant of dengue severity, particularly among vulnerable groups like young children and the elderly, it is essential to recognize that additional clinical factors (e.g., immune function, existing health conditions) can profoundly affect severity. Consequently, our approach forecasts severity with the recognition that the age alone could overlook the whole complication of the outcomes for patients.

The EDA reveals a reduced incidence of dengue cases in individuals over 60 years compared to other age groups; however, it is crucial to acknowledge that this demographic is frequently prone to significant health complications due to an array of underlying conditions, including compromised immune systems and comorbidities. Consequently, despite the reduced incidence, the probabilities of severe dengue could stay elevated in those over 60 years of age, potentially affecting the outcomes for this demographic in ways not evident from case statistics alone.

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Survey-based analysis of integrating Artificial Intelligence in Ayurveda practices

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Abstract— This paper aims to discuss the possibility of incorporating AI to Ayurveda which is a natural health care system. Thus, even though AI is capable to change the course of healthcare, Ayurveda is not actively adapting to new technologies, up to date. The field survey administered to the Ayurvedic practitioners aimed to assess their competence and sentiments over AI, to assess their awareness of AI and its usage, and perceived difficulties and limitations. The survey targeted over 50 individuals with majority of the participants being young at 90% and female at 60%. About 38% reported being moderately familiar and 6% were highly familiar with Ayurveda however, 22% of participants reported that they have no idea about AI while 12% reported they were very familiar with it. The challenges observed by the study were on the areas of privacy, data quality and culture. The study brings out about the adoption of AI among Ayurvedic professionals and promotion of precise ways and means. The limitations are small sample size, respondent bias in self-completed questionnaires and cross-sectional data collection. As for the current study limitations, the future studies should involve the larger and diverse sample, taking into consideration the change process of integrating AI in Ayurveda and, and developing culturally relevant AI programs. This would afford a more general idea of how AI could complement Ayurveda.

However, Ayurveda still fails to cope up with most of today's scientific and advanced technologies. Vimal Vijayan and Ajitha K (2024) show that Artificial Intelligence (AI) has the potential to revolutionize healthcare, and AI can enhance patient care, reduce costs,

Keywords— Ayurvedic, Artificial Intelligence (AI), Integration

I. INTRODUCTION

Ayurveda is a contemporary medical science which focuses on the holistic healing of the human body. According to Vimal Vijayan and Ajitha K (2024), Ayurveda is originated in India more than 3,000 years ago and it is an ancient system of natural medicine that focuses on overall health and well-being.

and optimize procedures by improving diagnosis and treatment capabilities by combining predictive analytics, personalized medicine, enhanced imaging, and robotic surgery. Also using algorithms, speech recognition and data analysis processes, AI can analyse large chunks of information such as the patient's behaviour and medical history, which enhances the diagnostic ability as well as the ability to develop unique treatments for individual patients. The incorporation of AI in Ayurveda will help to improve the access to traditional remedies and outcomes with developing personalized approach to therapy and relieving tasks. Vimal Vijayan and Ajitha K (2024) describe that several innovative firms are already successfully merging with AI with Ayurveda to provide individually healthcare treatments such as NirogStreet and Khosla Ventures- backed CureMetrix.

The present research will seek to use quantitative methods to examine the possibility of employing the application of artificial intelligence in Ayurveda while discussing the proposals of integrating ancient Ayurveda knowledge with modern technology to further progress in Ayurveda and enhance healthcare in today's world.

II. METHODOLOGY

As the research design, construction of a measuring instrument in form of questionnaire on the integration of Artificial Intelligence (AI) in Ayurveda was employed. The questionnaire used both closed and open questions and included demographics of the respondent and awareness and experience with Ayurveda and AI. First technique of recruitment involved purposive sampling from actual or potential populations. An online Google Form survey was conducted which was easily accessible and anonymous and received fifty responses from Ayurvedic users and learners in a week. Quantitative data included easy-to-understand quantitative raw data summaries and qualitative responses underwent quantitative thematic analysis to assess participants' overall awareness and attitude towards AI. However, the limitations as sampling bias and scope were accepted in this study. This methodology made clear and provided comparison on how AI incorporates into Ayurveda every time the study was to be undertaken.

III. RESULTS AND DISCUSSION

The thematic analysis of the survey data reveals several key insights into the integration of AI in Ayurveda. Demographic data indicates a predominantly young male audience, suggesting that engagement with Ayurvedic practices and AI may be more common among this group. Familiarity with Ayurveda is relatively high, with a majority having used Ayurvedic treatments, while familiarity with AI is less pronounced, with a significant portion of respondents only slightly familiar with it. Privacy concerns are notable, with varying levels of concern among respondents. Overall, there is cautious optimism about AI's potential to enhance Ayurvedic practices, though challenges such as data quality and cultural integration remain significant.

The statistical data analysis of the survey included regression and correlation techniques to explore relationships between variables such as familiarity with Ayurveda and AI, and their impact on perceived effectiveness and trust in AI applications. Regression analysis was employed to predict the influence of demographic factors on familiarity with AI and Ayurvedic treatments, while correlation analysis identified associations between respondents' trust levels in Ayurvedic treatments and their perceptions of AI's effectiveness. This approach provided deeper insights into how demographic variables and familiarity levels interact to shape attitudes towards the integration of AI in Ayurveda.

Regarding the objectives of the survey, the demographic data of the 50 participants offer significant insights into numerous attributes related to public awareness and knowledge on Ayurveda and AI. Figure 1 illustrates the age distribution among the respondents, segmented into four categories: 18-25 years, 26-35 years, 36-45 years, and 46-55 years of age. The greatest part of the chart, occupying 60%, hints at the predominant age in the sample, revealing numerous demographic peculiarities relevant to establishing the age demographic interested in Ayurvedic practices. This is supplemented by Figure 2, which shows gender representation, with 60% male and 40% female respondents, highlighting the importance of gender parity in the analysis.

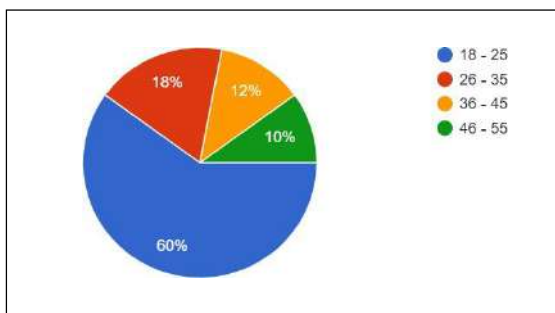


Figure 1. A pie chart of Age gaps of participants
Source: Survey Questionnaire conducted by DLS Nadavi,

KDU IRC 2024.

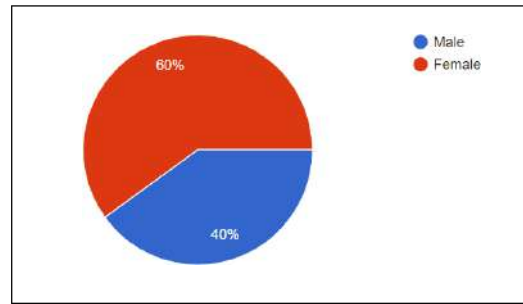


Figure 2. A pie chart of Gender of participants
Source: Survey Questionnaire conducted by DLS Nadavi,

KDU IRC 2024.

The familiarity levels with Ayurvedic medicine among the 50 participants are detailed in Figure 3, 52% responded 'Slightly familiar,' 38% 'Moderately familiar,' and 6% 'Very familiar.' This distribution indicates a continuity of familiarity, suggesting that expanding information could target other segments to increase awareness. Figure 4 shows that 82% of respondents have used Ayurvedic treatments, indicating their prevalence in the sampled population. Figure 5 reveals trust levels in Ayurvedic treatments and conventional medicine: 58% moderate trust, 34% slight trust, and 6% very high trust, providing insights into public attitudes towards these systems.

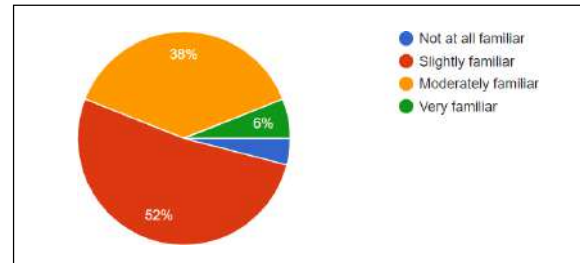


Figure 3. A pie chart of Familiarity with Ayurvedic Products
Source: Survey Questionnaire conducted by DLS Nadavi,
KDU IRC 2024.

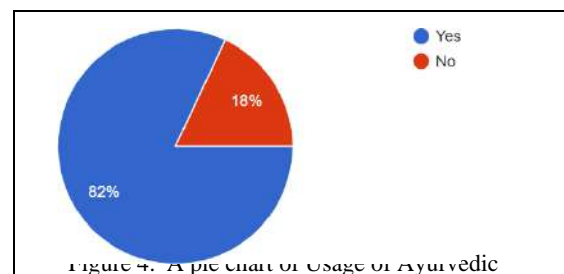


Figure 4. A pie chart of Usage of Ayurvedic
Source: Survey Questionnaire conducted by DLS Nadavi,

KDU IRC 2024.

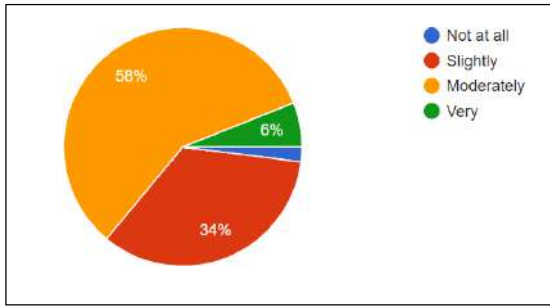


Figure 5. A pie chart of Trust of Ayurvedic treatments
Source: Survey Questionnaire conducted by DLS Nadavi, KDU IRC 2024.

Turning to AI, Figure 6 categorizes respondents' familiarity levels with artificial intelligence: 22% 'Not at all familiar,' 42% 'Slightly familiar,' 24% 'Moderately familiar,' and 12% 'Very familiar.' This distribution offers an understanding of the public's awareness regarding AI application. Figure 7 shows that 16% of respondents are aware of AI's uses in healthcare, reflecting a growing familiarity with AI's role in conventional medicine practices.

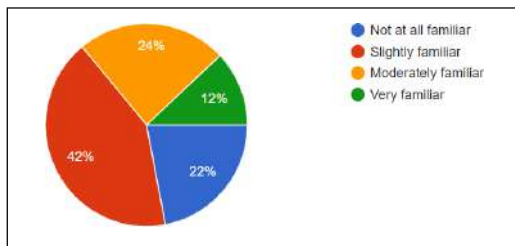


Figure 6. A pie chart of Familiarity with AI compared to conventional medicine

Source: Survey Questionnaire conducted by DLS Nadavi, KDU IRC 2024.

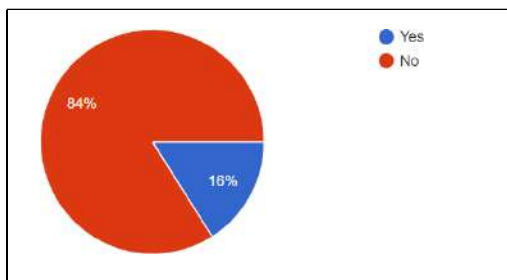


Figure 7. A pie chart of Awareness of any AI in Ayurveda
Source: Survey Questionnaire conducted by DLS Nadavi, KDU IRC 2024.

Figure 8 highlights the benefits of combining AI with traditional Ayurvedic medicine, including improved diagnostic accuracy, unique treatment plans, access to medical knowledge, and increased research and

moderately effective. Figure 10 expands on the perceived effectiveness of AI in generating Ayurvedic treatment plans, with 44% viewing it as moderately effective and 42% as slightly effective.

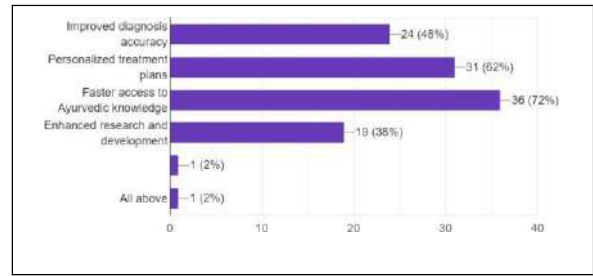


Figure 8. A pie chart of Benefits from AI in Ayurveda
Source: Survey Questionnaire conducted by DLS Nadavi, KDU IRC 2024.

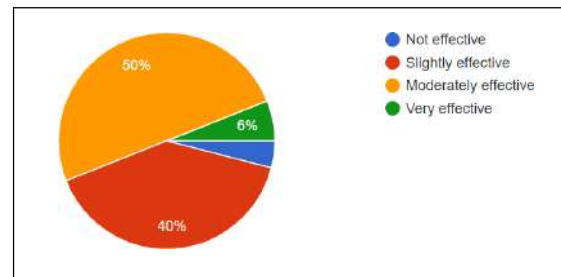
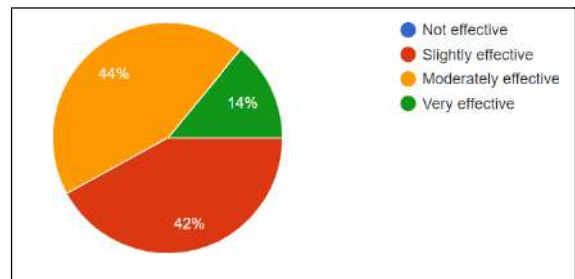


Figure 9. A pie chart of Effectiveness about AI could be diagnosing health conditions

Source: Survey Questionnaire conducted by DLS Nadavi, KDU IRC 2024.



development. Figure 9 depicts that most respondents believe AI integrated with Ayurvedic philosophies is

Figure 20. A pie chart of Effectiveness about AI in be creating
personalized plans

Source: Survey Questionnaire conducted by DLS Nadavi,
KDU IRC 2024.

Figure 11 indicates that 46% of participants find AI helpful for preventive healthcare based on Ayurveda, suggesting AI's potential in enhancing preventive care. Privacy concerns related to AI in healthcare are varied, as shown in Figure 12: 32% moderate concern, 38% slight concern, 22% significant concern, and 8% no concern. Addressing these concerns is crucial for ethical AI implementation in healthcare. Figure 13 outlines ideal AI features for Ayurveda, including accurate prescriptions, medication

indications, precise diagnostics, and wearable health devices. Finally, Figure 14 presents issues involved in implementing AI with Ayurvedic medicine, such as prescription accuracy, data quality, generational gaps, cross-cultural issues, and limited research material, highlighting the challenges in integrating modern AI innovations with traditional practices.

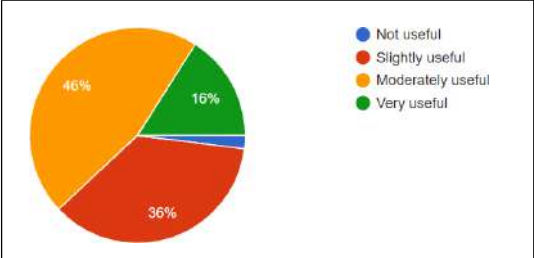


Figure 31. A pie chart of Use of AI in preventive Healthcare
Source: Survey Questionnaire conducted by DLS Nadavi,
KDU IRC 2024.

you have capitalised some letters unnecessarily

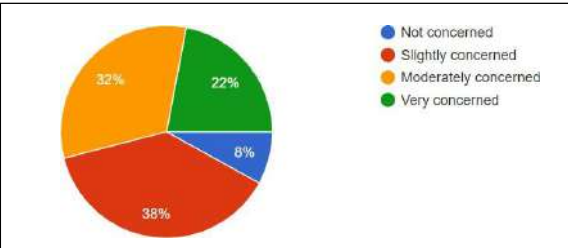


Figure 42. A pie chart of Privacy issues related to AI in
healthcare

Source: Survey Questionnaire conducted by DLS Nadavi,
KDU IRC 2024.

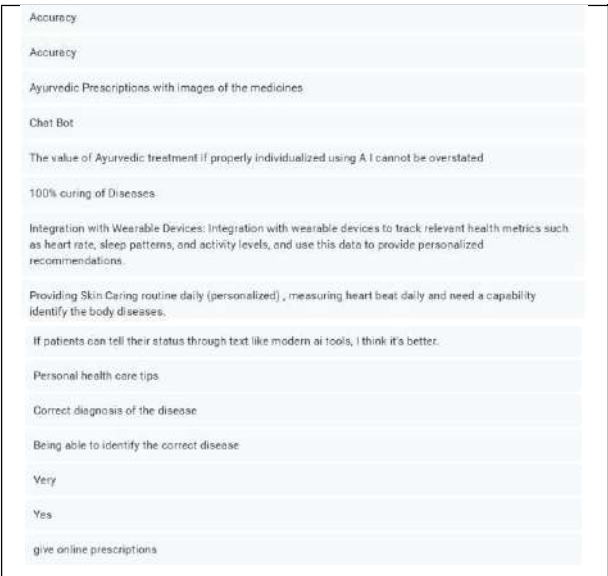


Figure 53. Responses for Features or Capabilities in AI-based
Ayurveda.

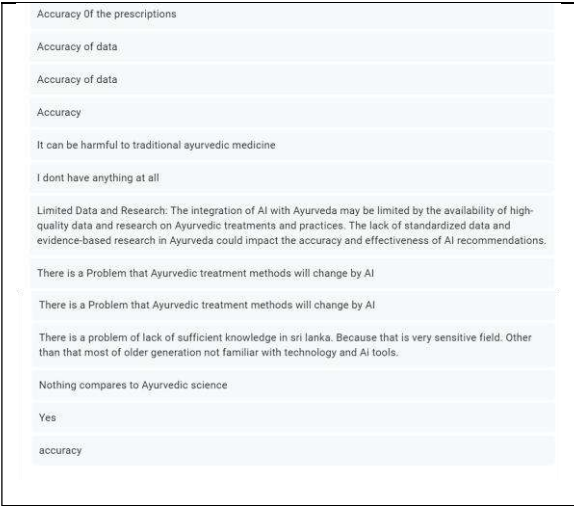


Figure 64. Responses for Concerns with integration of AI in
Ayurveda

Source: Survey Questionnaire conducted by DLS Nadavi,
KDU IRC 2024.

IV. CONCLUSION

From the survey, it can be concluded that while there is some awareness among the population about the applications of AI in Ayurveda, overall awareness of AI remains limited. Respondents are aware of AI's potential to enhance Ayurvedic practices, particularly in improving diagnostic precision, designing treatment regimens, and advancing research. There is some confidence in AI's ability to provide personalized treatments and preventive health care advice. However, several issues need addressing to enhance AI support for Ayurvedic medicine, including privacy concerns, accuracy of prescriptions, data quality and integrity, and cultural and generational differences. To address these challenges, consumers should seek AI-enhanced Ayurvedic services that prioritize data privacy and diagnostic accuracy while considering cultural and generational contexts. AI developers should focus on improving the accuracy and reliability of their algorithms by utilizing comprehensive data and continuously refining their systems. Collaboration with Ayurvedic practitioners is crucial for developing culturally relevant AI tools, fostering user acceptance. Additionally, building trust through robust data protection and clear governance policies is essential for successful AI integration into Ayurvedic practices.

Source: Survey Questionnaire conducted by DLS Nadavi,
KDU IRC 2024.

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I am an undergraduate student specializing in BSc. in Applied Data Science Communication in General Sir John Kotelawala Defense University in Ratmalana and, currently expanding my expertise by following a Postgraduate Diploma in Marketing Management in Sri Lanka Institute of Marketing. This unique combination of skills allows me to leverage data-driven insights to inform strategic marketing decisions, blending analytical proficiency with creative problem-solving.

Overall: good use of language and no significant errors

EDUCATION IN GOVERNMENT SCHOOLS GRADE 01 - 05) IN COLOMBO DISTRICT

Abstract - The study addresses the implementation of English medium instruction at government primary schools within the Colombo district from grades 1 - 5. It is a critical look at the various factors that would influence achievement in education: socio-economic background, teaching method, learning resources, teacher's qualification, parental involvement, and school infrastructure. A mixed methodology is used, and data is collected through online surveys from teachers, parents, and administrators. The result is such that success with English medium instruction has a very high and positive correlation with the availability of resources for learning, qualification of the teachers, and school infrastructure. Other factors consider the socio-economic status, quality in methodology and approaches to teaching and learning, and the home influence. The researchers conclude that there need to be direct efforts via strategic steps taken to ensure improvement in the allocation of resources, teacher training, and infrastructure. Recommendations would be to increase the budget allocation for teaching resources, constant teacher training, and programs to engage parents further in their children's education. The study advocates for future research to explore the long-term effects of English medium education through longitudinal studies. Incorporating qualitative data is also suggested to complement the quantitative findings, providing a more comprehensive understanding of the factors at play. The study emphasizes the need for targeted interventions to address the critical areas of resources, teacher qualifications, and infrastructure to enhance the effectiveness of English medium education in primary schools within the Colombo district.

Keywords: English Medium Instruction, Socio-economic Background, Learning Resources, Teacher Qualifications, Parental Involvement, School Infrastructure

I. INTRODUCTION

The history of English-medium education in Sri Lanka is complicated; initially, it served a small, illiterate elite. English-speaking Sri Lankans benefited from government employment and teaching opportunities during British control, which separated them from the rest of the population (Liyanage, 2021). While the government increased access to state-run schools and provided funding to private schools in 1870, the quality of education did not improve (Mel, 2021). Following 1948's independence, the government made education a top priority, greatly expanding the number of

institutions, learners, and instructors while also enacting reforms including standardized testing and a national curriculum to improve the standard (Liyanage, 2021).

III. PROBLEM STATEMENT

Currently, education is compulsory in Sri Lanka, with nearly 99% of primary-school-age children enrolled in school (Ministry of Education, 2020). Despite this high enrolment rate, quality issues remain. Government schools in Colombo District offer English medium education from grades 1 - 5, aiming to provide a strong foundation in English. Hence, the study was conducted to answer the question: what are the main factors that positively and significantly impact the English medium instructions at the primary levels in government schools of Colombo.

IV. RESEARCH OBJECTIVES

The research aims to find the main factors that positively influence the effectiveness of English medium education at the primary levels in government schools of Colombo. The objectives are to identify the positive and significant relationships as follows:

- between the socio-economic background of students and English language proficiency.
- between the quality of English language teaching methods and English language proficiency.
- between available English language learning resources and English language proficiency in grades 1 to 5 classrooms.
- between teacher qualifications and training and English language proficiency.
- parental involvement and support on English language proficiency.
- between school infrastructure and facilities and English language proficiency.

III. LITERATURE REVIEW

The effectiveness of English medium education in government schools can be understood through several theoretical lenses. Sociocultural theory emphasizes that learning is inherently social and shaped by cultural context, suggesting that students learn English more effectively through meaningful social interactions and culturally relevant content (Lantolf, 1995; Fahim, 2012). Educational psychology theories, such as self-determination theory, highlight the importance of autonomy, competence, and relatedness in fostering intrinsic motivation and optimal learning outcomes (Lindsay, 2007). Engaging students in interactive activities and fostering self-efficacy are crucial for

enhancing language proficiency and academic success (McInerney, 2005; Slavin, 2018). Language acquisition theories provide further insights into the processes of learning a second language. Behaviorist theories emphasize imitation, reinforcement, and practice, while cognitive theories focus on memory and problem-solving processes (Gülbeyaz, 2012; Mehrpour, 2015). Social capital theory underscores the role of social networks in providing resources and support, enhancing language acquisition and academic performance (Putnam, 2000; Siisiainen, 2003). Various factors influencing the effectiveness of English medium education in government schools. Socio-economic background significantly affects English proficiency, with students from higher socio-economic statuses exhibiting better language skills due to increased access to resources and support (Busher, 2020; Vega, 2011).

Teaching methodologies also play a crucial role; communicative language teaching (CLT) has been shown to enhance fluency and communicative competence (Wang, 2021) as resource scarcity hampers effective learning (Do, 2022; UNESCO, 2016). Teacher qualifications and ongoing professional development positively impact student outcomes (Wang & Smith, 2019). Parental involvement, such as shared reading and language-rich home environments, significantly boosts language proficiency (Garcia, 2016). Additionally, quality school infrastructure, including well-equipped classrooms and modern amenities, enhances student engagement and learning outcomes (Lee, 2019).

V. RESEARCH METHODOLOGY

A. Conceptual Framework

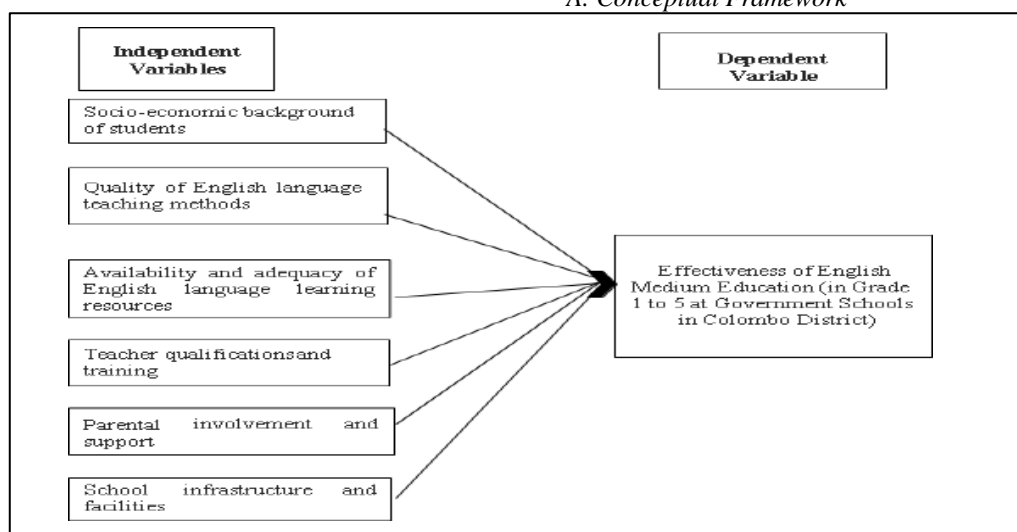


Figure 1- Conceptual framework
Source: developed by Author (2024)

The conceptual framework outlines the relationships between various factors and their impact on English medium education. It integrates theories from sociocultural, educational psychology, language acquisition, social capital, motivation, cultural capital, and communicative language teaching (Bandara, 2016).

B. Development of Hypotheses

The development of hypotheses for this study explores several factors impacting students' English language proficiency. The hypotheses posit positive and significant relationships between English language proficiency and the following variables: students' socio-economic background, the quality of English language teaching methods, the availability of learning resources in grades 1 - 5 classrooms, teacher qualifications, and training, parental involvement and support, and school infrastructure and facilities. Each of these factors is expected to contribute meaningfully to the student's ability to achieve proficiency in the English language, highlighting the multifaceted nature of language acquisition in an educational setting.

C. Research Philosophy

The research adopts a positivist approach, emphasizing objective, measurable results derived from empirical evidence. It employs scientific methods to analyze factors influencing English-medium education in government schools, aiming for an unbiased understanding through statistical analysis.

D. Research Approach

The study employs a quantitative approach, focusing on numerical data to analyze patterns and connections influencing the effectiveness of English medium instruction in government schools. This method supports measurable evidence, hypothesis testing, and causal relationships through statistical analysis, ideal for identifying factors.

E. Research Instruments

Data are collected using online surveys distributed to teachers, parents, and administrators. The surveys include questions on socio-economic background, teaching methods, learning resources, teacher qualifications, parental involvement, and school infrastructure (Jayasinghe, 2015).

F. Sampling

A convenience sample of 384 respondents, including teachers, parents, and administrators, was chosen for their availability and willingness to participate. Data was collected through online surveys, which provided quick and broad geographic coverage. While it facilitates data collection efficiency, it may introduce bias and limit generalizability.

G. Data Collection Methods

The data collection process will involve:

- 1) *Survey design*: The questionnaire will contain structured questions to provide relevant data about the factors affecting the English-medium instructions.
- 2) *Survey administration*: The electronic mail and the online study sent to the targeted respondents are part of the approach aimed at administering online surveys.
- 3) *Data collection*: The data derived from the online survey response will be indispensable and anonymous. The surveys will remain active for the determined period, of which the sample size is considerable enough to involve themselves in the study.
- 4) *Data triangulation*: This will be attained by cross-validation of the survey questionnaire information with the information from the existing literature data from the online source.

H. Data Analysis Method

Using a cross-sectional design, it captures a snapshot of factors influencing English medium instruction at one point in time. Quantitative tools like descriptive statistics (mean, median, mode) and inferential analysis (correlation, regression) are applied using SPSS 27 for thorough data analysis and interpretation. The elements influencing English language proficiency in grades 1 through 5 in government schools in the Colombo district are further explored in-depth by the qualitative analysis. A more thorough understanding of the complicated procedures that occur is provided by this analysis's incorporation of qualitative insights. The integration of quantitative and qualitative findings highlights the complex interplay between socio-economic background, quality of teaching methods, availability of resources, teacher qualifications, parental involvement, and school infrastructure. Addressing these factors through targeted interventions and policies is essential for enhancing the effectiveness of English-medium instruction and improving educational outcomes.

VI. RESULTS

the analysis of data collected through online surveys, discussing the findings and their implications for English medium education in the Colombo District. The study shall encompass descriptive statistics, regression analysis, correlation analysis, validity and reliability testing, and hypothesis testing

A. Discussion of Demographic Data

The demographic data of respondents, including age, gender, role in school, and educational background, provide context for the analysis (Perera, 2018).

1) *Age distribution*: The age distribution of respondents ensures a diverse and representative sample. The five age groups are under 20, 20–29, 30–39, 40–49, and 50 and above. The largest group is 20–29 years old, making up 26.0% of the sample. Those aged 50 and above constitute 21.9%, individuals under 20 represent 17.7%, and those aged 40–49 account for 19.8%. The broad range of ages ensures varied perspectives, as views on education differ across life stages.

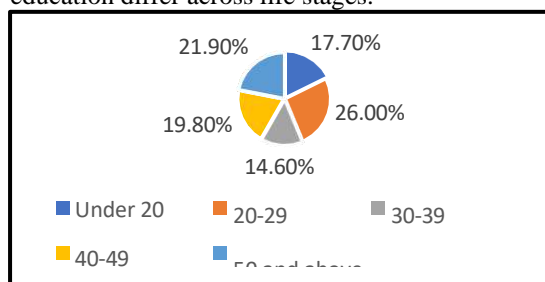


Figure 2 - Age of respondents

Source: SPSS 27: Developed by Author (2024)

2) *Gender distribution*: The survey's gender distribution shows 40.9% men and 59.1% women, indicating higher female participation. This may impact responses related to educational practices and outcomes, reflecting substantial female involvement in education roles.

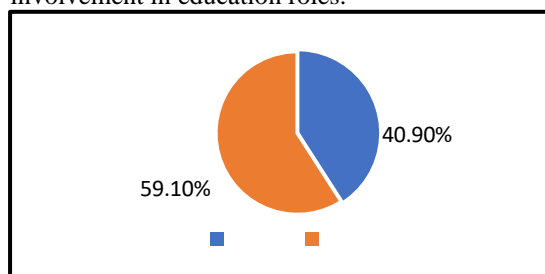


Figure 3 - Gender of respondents

Source: SPSS 27: Developed by Author (2024)

3) *Role in school*: The sample includes teachers (52.3%), parents (25.3%), and school administrators (22.4%). Teachers' insights are crucial due to their direct involvement in education delivery. Parents' views reflect the impact on students.

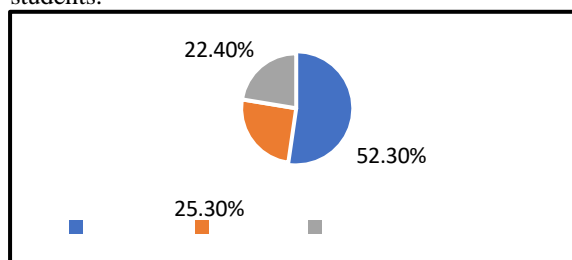


Figure 4 - Role in School of Respondents

Source: SPSS 27: Developed by Author (2024)

4) *Educational background:* Respondents' educational backgrounds are diverse: 36.2% have secondary education, 29.5% hold bachelor's degrees, 20% have master's degrees, and 11% possess doctorates, while 3.4% completed only primary school.

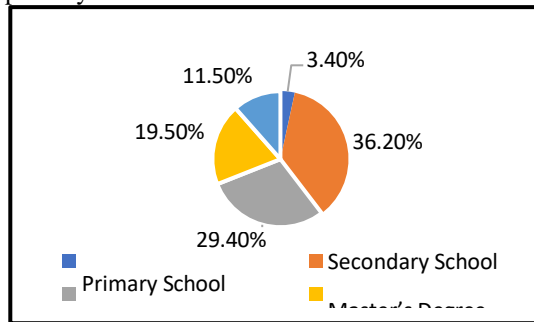


Figure 5 -Educational Background

Source: SPSS 27: developed by Author (2024)

B. Descriptive Analysis

Descriptive statistics reveal insights into the central tendency and variability of the data. Mean scores indicate positive perceptions of various factors influencing English medium education, with the highest mean for teaching techniques (IV2) at 80.16, and the lowest for parental support (IV5) at 77.25. Standard deviations highlight variability, with school infrastructure (IV6) having the highest at 18.197, indicating diverse opinions. The effectiveness of English medium education (DV) has the lowest standard deviation (12.687), suggesting consistent perceptions.

Table 2 – Descriptive Analysis of variables

Statistics		IV1	IV2	IV3	IV4	IV5	IV6	DV
N	Valid	384	384	384	384	384	384	384
Mean		78.13	80.16	79.31	78.88	77.25	77.93	77.46
Median		80.00	85.00	80.00	85.00	85.00	80.00	80.00
Mode		90	90	85	90	85	80	80
Std. Deviation		16.331	17.195	14.658	18.085	17.326	18.197	12.687
Variance		266.710	295.667	214.862	327.072	300.200	331.146	160.965
Skewness		-1.330	-1.486	-.864	-1.396	-1.602	-1.272	-.583
Std. Error of Skewness		.125	.125	.125	.125	.125	.125	.125
Kurtosis		1.693	1.103	.200	1.556	1.222	1.367	-.066
Std. Error of Kurtosis		.248	.248	.248	.248	.248	.248	.248

Source: SPSS 27: developed by Author (2024)

C. Correlation Analysis

Table 3 – Correlation Analysis

		IV1	IV2	IV3	IV4	IV5	IV6	DV
IV1	Pearson Correlation	1	.144**	.872**	.941**	.030	.893**	.703**
	Sig. (2-tailed)		.005	.000	.000	.558	.000	.000
	N	384	384	384	384	384	384	384
IV2	Pearson Correlation	.144**	1	.382**	.125*	.295**	.178**	.714**
	Sig. (2-tailed)	.005		.000	.014	.000	.000	.000
	N	384	384	384	384	384	384	384
IV3	Pearson Correlation	.872**	.382**	1	.807**	.117*	.757**	.854**
	Sig. (2-tailed)	.000	.000		.000	.022	.000	.000
	N	384	384	384	384	384	384	384
IV4	Pearson Correlation	.941**	.125*	.807**	1	-.028	.939**	.730**
	Sig. (2-tailed)	.000	.014	.000		.582	.000	.000
	N	384	384	384	384	384	384	384
IV5	Pearson Correlation	.030	.295**	.117*	-.028	1	.003	.640**
	Sig. (2-tailed)	.558	.000	.022	.582		.956	.000
	N	384	384	384	384	384	384	384
IV6	Pearson Correlation	.893**	.178**	.757**	.939**	.003	1	.734**
	Sig. (2-tailed)	.000	.000	.000	.000	.956		.000
	N	384	384	384	384	384	384	384
DV	Pearson Correlation	.703**	.714**	.854**	.730**	.640**	.734**	1
	Sig. (2-tailed)	.000	.000	.000	.000	.000	.000	
	N	384	384	384	384	384	384	384

**, Correlation is significant at the 0.01 level (2-tailed).

*, Correlation is significant at the 0.05 level (2-tailed).

Source: SPSS 27: Developed by Author (2024)

Correlation analysis reveals significant relationships between factors influencing English-medium education effectiveness. Socioeconomic background (IV1) strongly correlates with teacher qualifications (IV4), school infrastructure (IV6), and learning resources (IV3), with coefficients of 0.941, 0.893, and 0.872, respectively. Quality teaching methods (IV2) moderately correlate with all IVs and the dependent variable (DV). Learning resources (IV3) highly correlate with DV (0.854), emphasizing their critical role. Teacher qualifications (IV4) show strong correlations with IV1, IV3, IV6, and DV (0.730). Parental involvement (IV5) moderately affects DV. School infrastructure (IV6) significantly correlates with DV (0.734). The analysis underscores the importance of socioeconomic factors, quality teaching, resources, and infrastructure for educational success.

D. Regression Analysis

Regression analysis identifies the most significant predictors of English language proficiency, providing insights into the relative importance of different factors (Samarasinghe, 2019). The multiple regression analysis identifies key predictors of English medium education effectiveness in government schools. The correlation coefficient (R) of 0.944 indicates a strong positive relationship, while the R Square value of 0.892 shows that 89.2% of the variance is explained by the model. The Adjusted R Square value is 0.890, and the standard error is 4.203, suggesting accurate predictions. The model is statistically significant with an F Change of 518.811 and a p-value of 0.000. The Durbin-Watson statistic of 1.595 indicates mild positive autocorrelation. Overall, the model demonstrates the importance of the independent variables in predicting educational effectiveness.

Table 4 – Regression Analysis

Model Summary										
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. Change	
1	.944 ^a	.892	.890	4.203	.892	518.811	6	377	.000	1.595
a. Predictors: (Constant), IV6, IV5, IV2, IV3, IV1, IV4										
b. Dependent Variable: DV										

Source: SPSS 27: Developed by Author (2024)

E. Hypotheses Testing

Hypotheses testing confirms the positive and significant relationships between the identified factors and English language proficiency (Bandara, 2016). The hypothesis analysis evaluates the significance of various factors on English medium education effectiveness. Socio-economic background (IV1) has a strong positive impact (B=0.791, t=15.942, p=0.000). English teaching methods (IV2) show a modest positive effect (B=0.035, t=2.207, p=0.028). Learning resources (IV3) have a significant positive influence (B=0.882, t=24.468,

p=0.000). Teacher qualifications (IV4) are impactful (B=0.311, t=6.597, p=0.000). Parental involvement (IV5) significantly enhances outcomes (B=0.202, t=15.376, p=0.000). School infrastructure (IV6) also positively affects education (B=0.323, t=9.050, p=0.000). These findings emphasize the importance of socioeconomic background, resources, and parental involvement in educational success

Table 5 – Coefficients of hypothesis

Coefficients ^a						
Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B	Std. Error	Beta		
1	(Constant)	6.774	1.535		4.412	.000
	IV1	.791	.050	1.018	15.942	.000
	IV2	.035	.016	.047	2.207	.028
	IV3	.882	.036	1.019	24.468	.000
	IV4	.311	.047	.443	6.597	.000
	IV5	.202	.013	.276	15.376	.000
	IV6	.323	.036	.463	9.050	.000
a. Dependent Variable: DV						

Source: SPSS 27: Developed by Author (2024)

VII. DISCUSSION AND CONCLUSION

A. In this correlational study on English-medium education effectiveness in Colombo's government schools, several key findings emerged:

1) *Students' Socioeconomic Background (IV1):*

There was a modest positive correlation between socioeconomic status and educational effectiveness. Students from better socioeconomic backgrounds,

with access to resources like books, tutors, and a supportive home environment, showed improved academic performance, particularly in English proficiency.

2) *Teaching Methods (IV2)*: Strong positive correlations were found between effective teaching methods and learning outcomes. Pedagogical approaches emphasizing experiential learning, group

discussions, and multimedia resources significantly enhanced language fluency and comprehension among students.

3) *Learning Resources (IV3)*: Availability and sufficiency of learning resources showed the most vital correlation with educational effectiveness. Access to digital resources, textbooks, and supplementary materials positively influenced language learning outcomes and overall academic achievement.

4) *Teacher Qualifications and Training (IV4)*: The quality of teachers had a high positive correlation with instructional effectiveness. Supported by continuous professional development, well-qualified teachers played a crucial role in student learning and achievement in English-medium education.

5) *Parental Involvement (IV5)*: Moderate but significant correlations were observed between parental involvement and educational outcomes. Parental support through activities like homework assistance and participation in school events contributed to student engagement and academic success.

6) *School Infrastructure and Facilities (IV6)*: Positive correlations were found between well-equipped school infrastructure and educational effectiveness. Adequate classrooms, libraries, labs, and recreational areas were crucial in providing a conducive learning environment for students.

B. Recommendations Implications for Policy and Practice aims to enhance educational performance through strategic interventions across multiple domains:

1) *Enhancing Learning Resources*: Ensuring classrooms are well-equipped with up-to-date textbooks, digital tools, and supplementary materials is crucial for improving educational performance. Investments in educational technology and partnerships with businesses and NGOs can help bridge resource gaps and provide equitable access to learning tools.

2) *Investing in Teacher Training*: Continuous professional development is essential to equip teachers with contemporary pedagogical methods and classroom management skills. Policies should support ongoing training and incentives for further education to enhance teaching effectiveness and adaptability to diverse student needs.

3) *Improving School Infrastructure*: Upgrading physical facilities including libraries, language labs, and basic infrastructure is necessary to create conducive learning environments. Government funding should prioritize equitable distribution of resources across schools, especially in underserved communities, to support holistic development and educational equity.

4) *Supporting Socioeconomic Diversity*: Addressing socioeconomic barriers through financial aid, scholarships, and community support initiatives is critical. Educational programs should raise awareness and provide support systems.

5) *Engaging Parents*: Strengthening school-family partnerships through proactive engagement

strategies like workshops, regular communication, and parent-teacher associations enhances parental involvement in students' education.

VIII. CONCLUSION

The study provides valuable insights into the factors influencing the effectiveness of English medium education in the Colombo District. Key factors include socioeconomic background, teaching techniques, learning resources, teacher qualifications, parental participation, and school infrastructure. Implementing policies that improve these areas can create supportive, resource-rich environments, leading to academic excellence and equitable opportunities. Continuous research and adaptation of educational practices are essential for long-term success in English medium education.

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The Effect of Using Audio Visual Materials with Subtitles on Second Language Vocabulary Learning

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Abstract - The main purpose of this study was to examine the impact of watching audiovisual materials with subtitles on second language vocabulary learning. 117 adult learners of English who are in pre-intermediate were selected for this study and they were divided into four experimental groups (A, B, C & D) and one control group (E) randomly. Experimental group A watched the videos with subtitles only once, B without subtitles only once, C with subtitles twice and D without subtitles twice. All groups watched the same three videos during the experimental session. All of them took a pre and post-test that tested their receptive and productive knowledge of 15 target words occurred in the videos. The control group took only the pre and post-tests. Data analysis indicated that those who were in Groups A, B, C and D were able to increase their receptive knowledge of vocabulary after watching the videos with or without subtitles. Those who watched videos without subtitles only once (B) did not demonstrate any significant gains in the productive vocabulary knowledge although groups A, C and D were able to. The control group (E) did not show any difference between pre and posttests. The findings indicate that video watching in general can increase L2 learners' receptive vocabulary knowledge even if those do not contain subtitles. If learners watch videos several times without subtitles, they may also be able to increase their productive vocabulary knowledge too. Therefore, teachers should encourage L2 learners to watch videos to enhance their vocabulary growth.

Key words: vocabulary, acquisition, subtitles,

I. INTRODUCTION

Vocabulary refers to the collection of words employed by individuals or groups to communicate and express ideas, forming the foundation of language (Hiebert, 2007). It includes words, phrases, or word combinations that carry specific meanings. Lehr et

al. (2004) define vocabulary as the understanding of words and their meanings. It means learners must grasp not only words but also their respective meanings. The acquisition and development of vocabulary is a complex process influenced by various factors, including exposure, context, frequency, and individual differences. According to Richards and Renandya (2002), exposure to radio, television, and native speakers supports learners in acquiring vocabulary. The proficiency level of a second language learner is determined by the number of words they possess.

In experimenting the word knowledge, two major categories can be identified as receptive vocabulary and productive vocabulary. Learners acquire receptive vocabulary through listening and reading and productive vocabulary are the words which are used in writing and speaking (Lehr, Osborn, Hiebert; 2004). In one hand, people learn receptive words from language input such as reading input or listening input and productive vocabulary can be considered as the language output which is gained through speaking and writing. According to Nation and Snowling (1997), children with a wider receptive vocabulary exhibit superior reading comprehension, achieve higher academic success, and possess overall better language skills.

Incidental vocabulary learning (IVL) refers to the acquisition of new words in an unplanned and implicit manner through various mediums, such as reading, listening, watching videos, and everyday conversations (Webb & Nation, 2017). Incidental vocabulary learning is crucial in second language development because it allows learners to acquire new vocabulary in meaningful contexts (Krashen, 1989).

Listening input, such as audio and video materials, can also be considered a valuable source of incidental vocabulary learning. Listening to songs, watching TV news, films, documentaries, cartoons, and attending lectures are some of the

activities that promote incidental learning. Vidal (2003) has noted that 16% of vocabulary is acquired through listening, and learners can retain 8.2% of the vocabulary after a four-hour period, according to a study on vocabulary learning through academic listening. Maneshi (2017) has pointed out that listening to songs is a receptive skill that encourage learners to acquire more vocabulary as words are repeated multiple times. Ronan Brown, Rob Waring, and Sangrawee Donkaewbua (2008) suggest that the combination of visual and auditory input provided by reading-while-listening enhances vocabulary acquisition. Nermeen Singer (2022) has pointed out that English cartoons had a positive impact on the participants' vocabulary acquisition.

In understanding the impact of audio video input with subtitles on Second Language Vocabulary Acquisition, Zahmatkesh and Ebrahim (2021) highlight that teachers have been incorporating audiovisual materials into L2 teaching in ELT classrooms for the past two decades. Ayand and Shafiee (2016) argue that subtitles serve as a powerful tool for improving language skills, advocating for more innovative, creative, and motivational language teaching practices. Notably, movies have been found to positively impact learners' motivation to acquire a new language (Tajgozari, 2019). Audiovisual materials with subtitles can be considered highly effective pedagogical tools that support the improvement of second language listening and reading comprehension. Subtitles enable learners to visualize the dialogue and provide additional support in understanding the content of the video (Danan, 2004).

Movies and videos can be highly recommended as powerful tools in English language teaching due to their effective combination of audio input and rich visual impact (Reese, 1987) and they can be used to teach English vocabulary while adding an element of fun and motivation. According to

Miller (2014), a movie or video with bilingual subtitles retains the original audio track in a foreign language while providing a transcript in the original language and subtitles in the viewer's native tongue. This allows learners to read and hear dialogue in the foreign language while still having access to a translation. J. N. Hook and William H. Evans (1982) suggest that audiovisual media can capture students' attention and provide a student-friendly learning experience in the English language classroom. Azhar (2011) points out some drawbacks of using movies in the teaching and learning process, such as the time-consuming nature of employing movies, the changing visuals that may hinder students' ability to follow the conveyed information, and the occasional mismatch between films and the specific learning needs and objectives.

The use of subtitles in films can be traced back to the 1970s (Cintas, 2005), but it was in the 1980s that subtitles were initially implemented in English Language Teaching as a strategy to enhance learners' motivation, attention, and reduce stress (Burger, 1989; Froehlich, 1988; Grimmer, 1992; Vanderplank, 1988). Consequently, numerous studies were conducted in the 1990s to investigate the impact of subtitled videos on second language learning. Researchers such as Baltova (1999), Danan (1992), Garza (1991), Markham (1993), and Neuman & Koskinen (1992), Paul L. Markham and Lizette A. Peter (2001), Patrícia Albergaria Almeida and Patrícia Dinis Costa (2014), Chang (2004), Danan (2004), Bravo (2005), Zanon (2006), Cintas (2005), Cakir et al. (2006), Basuki et al. (1991), Nasution (2005) Peters et al. (2016), Maribel Montero et al. (2014), Winke, Gass, and Sydorenka (2010), Danan (2004) conducted experiments in this field and they all have proved that subtitles are positively impacted on second language vocabulary learning. The introduction of media

such as TV, videos, and the internet motivated students in the classroom and influenced the effects of subtitles on foreign language learning (Eken, 2003).

Overall, the research findings demonstrate a positive impact of watching subtitled videos on vocabulary development. These studies have primarily focused on school students or undergraduates learning English as a second language across different regions. However, no published research paper specifically investigates the effect of audiovisual materials with subtitles on second language vocabulary learning within the local context of Sri Lanka.

This study has focused two research gaps namely context gap and theoretical gap. The context gap is there is not any studies conducted in local context regarding this topic and theoretical gap is, this study has been designed covering different aspects namely watching bimodal subtitles with or without subtitles only one time or two times. But, previous studies were conducted separately without combining all these aspects together. Additionally, the study seeks to explore the potential of incorporating this method into the Sri Lankan English language teaching and learning process as an effective approach for acquiring new vocabulary.

II.METHODOLOGY

The sample of this study includes 31 male and 86 female undergraduates who possess the intermediate level of English proficiency and they were divided into five groups randomly, Four experimental groups were labeled as A, B, C and D and one control group was labeled as E. Three documentary video clips less than 5 minutes in length were chosen for this study as a language input and five target words were selected from each videos which are not repeated by using the Lex tutor word sorter online version accessible at <https://www.lextutor.ca/vp/comp/>. The

pre-test and post-test were designed including two activities to test the receptive vocabulary and productive vocabulary knowledge of participants based on each videos.

The first task assessed the participants' knowledge of receptive vocabulary and it was designed in the multiple-choice question format. The second task was a cloze test, with the questions designed to gauge the participants' productive vocabulary knowledge. Five target words and five distracting words that are not in the video script were included in each task. The planned activities will be conducted in a separate soundproof classroom to minimize disturbances and after getting the consent of the participants and explaining the purpose of this study, the background questionnaire and the proficiency test will be given to all participants. The pre-test was conducted before the treatment sessions and the post test was conducted after the treatment sessions. During the treatment sessions, two experimental groups (A & B) were able to watch 3 videos with subtitles one time or two times consequently and other two experimental groups (C & D) were able to watch 3 videos without subtitles one time or two times accordingly. Control group (E) was subjected to only for pre-test and post-test and that group did not get an opportunity to watch the videos with or without subtitles. Vocabulary Knowledge Scale (VKS) which was introduced by Wesche & Paribakht (1996) was applied in this study to measure to rate their level of knowing a word in terms of both receptive and productive knowledge at the end of the data collection. To achieve the goals of this study, the carefully gathered data were subjected to a quantitative analysis utilizing the relevant instruments. To investigate the differences in the sample's performance between the pre- and post-tests, the gathered data from each group was arranged in Excel sheets

and subjected to quantitative analysis using SPSS version 23.

III.RESULTS

SPSS version 23 is used for the analysis and interpretation of the scientifically gathered data, and certain data were excluded for different reasons. To preserve the accuracy and consistency of the data, participants who understood more than three target terms were mostly disqualified from this study. Lastly, an analysis of the 117 data was conducted to find out how vocabulary learning for second languages is impacted by audio-visual materials with subtitles.

Wilcoxon Signed Rank tests were used to assess whether there were any group differences in the pre- and post-test results for the entire sample. The results indicate that all combinations show a statistically significant increase in vocabulary knowledge (both receptive and productive; $p < .001$) for the entire sample, with a large effect size in nearly all combinations. The difference between V1PreT2T and V1postT2T has a medium to high effect size ($r = 0.42$). The values are summarized in Table 1.

Table 1: Pre and post-test difference in the overall sample

	I.		
	<i>Z</i>	<i>p</i>	<i>r</i>
V1PreT1T- V1PostT1T	6.032	< 0.001	0.56
V1PreT2T- V1postT2T	4.480	< 0.001	0.42
V2PreT1T- V2PostT1T	5.555	< 0.001	0.52
V2PreT2T- V2PostT2T	5.067	< 0.001	0.47
V3PreT1T- V3PostT1T	6.717	< 0.001	0.62
V3PreT2T- V3PostT2T	5.273	< 0.001	0.49

A. Group Comparisons

The Wilcoxon Signed Rank test was utilized to examine any performance variations between pre- and post-tests across various groups. These were the group definitions provided: Using the following codes: A = 1 video watched once, B = 1 video watched without subtitles, C = 2 videos watched with subtitles, D = 2 videos watched

without subtitles, E = control group. The analyses show that, for all instances (Videos 1, 2, and 3), there is a statistically significant difference between the pre- and post-tests in both categories of vocabulary knowledge (receptive and productive), with a large effect size ($r > 0.5$) in Group A, which viewed the videos with subtitles once ($n = 22$). These results would suggest that watching movies with subtitles, even if they are only exposed to them once, can help pre-intermediate level learners gain more productive and receptive vocabulary knowledge. These results are summarized in Table 2.

II.

Table 2: Pre and post-test difference in group A

	<i>Z</i>	<i>p</i>	<i>r</i>
V1PreT1T- V1PostT1T	3.250	.001	0.69
V1PreT2T- V1postT2T	2.994	.003	0.63
V2PreT1T- V2PostT1T	3.448	<.001	0.73
V2PreT2T- V2PostT2T	3.419	<.001	0.72
V3PreT1T- V3PostT1T	3.810	<.001	0.81
V3PreT2T- V3PostT2T	2.778	.005	0.59

As the table 3 indicates, a significant difference can be seen statistically between the pre-test and the post-test in the receptive vocabulary knowledge in Videos 2 and 3 with a medium effect size ($r = 0.42$ and $r = 0.44$) among the participants in Group B that watched videos without subtitles only once ($n = 23$). However, on all other occasions, there is not statistically significant variation in their performance between pre and post-tests. These findings may imply that pre-intermediate level learners are not able to expand their productive vocabulary knowledge by watching videos if they are exposed to those only once, without subtitles. On the other hand, students could be able to broaden their vocabulary receptive

knowledge by watching films with subtitles.

Table 3: Pre and post-test difference in Group B

	<i>Z</i>	<i>p</i>	<i>r</i>
V1PreT1T-V1PostT1T	1.428	.153	0.29
V1PreT2T-V1postT2T	1.327	.185	0.27
V2PreT1T-V2PostT1T	2.042	.041	0.42
V2PreT2T-V2PostT2T	1.199	.230	0.24
V3PreT1T-V3PostT1T	2.141	.032	0.44
V3PreT2T-V3PostT2T	1.040	.298	0.13

Based on the analysis, there is a statistically significant difference in both categories of vocabulary knowledge (receptive and productive) between the pre-test and the post-test on all occasions (Videos 1, 2, and 3), with a substantial effect size ($r > 0.5$) in Group C. This group ($n = 25$) participated in the experiment by watching each video twice with subtitles. These results would suggest that, with the use of subtitles, pre-intermediate level students might improve their receptive and productive vocabulary knowledge by watching the same movie repeatedly. These results are summarized in Table 4.

Table 4: Pre and post-test difference in Group C

	<i>Z</i>	<i>p</i>	<i>r</i>
V1PreT1T-V1PostT1T	4.278	<.001	0.85
V1PreT2T-V1postT2T	3.236	.001	0.64
V2PreT1T-V2PostT1T	3.589	<.001	0.71
V2PreT2T-V2PostT2T	3.835	<.001	0.76
V3PreT1T-	4.123	<.001	0.82

V3PostT1T

V3PreT2T-V3PostT2T	4.451	<.001	0.89
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The results of Group D, which viewed each video twice without subtitles ($n = 21$), are shown in Table 5. As can be seen, there is a statistically significant difference between the pre- and post-tests in the receptive vocabulary knowledge in all videos, with small effect sizes in Video 1 ($r = 0.08$) and large effect sizes in Videos 2 ($r = 0.2$) and 3 ($r = 0.87$) for this group. Regarding the productive vocabulary knowledge, there is a statistically significant difference between the pre- and post-tests in Videos 2 and 3, with a large effect size ($r = 0.53$ and $r = 0.52$). However, this is not evident in the results for Video 1. These results might indicate that, even in the absence of subtitles, pre-intermediate level students are likely to improve their receptive vocabulary knowledge after watching the same video twice. Through the experience of viewing videos without subtitles, they might also be able to expand their useful vocabulary.

Table 5: Pre and post-test difference in Group D

	<i>Z</i>	<i>p</i>	<i>r</i>
V1PreT1T-V1PostT1T	3.808	<.001	0.08
V1PreT2T-V1postT2T	1.493	.135	0.32
V2PreT1T-V2PostT1T	2.867	.004	0.62
V2PreT2T-V2PostT2T	2.447	.014	0.53
V3PreT1T-V3PostT1T	4.021	<.001	0.87
V3PreT2T-V3PostT2T	2.402	.016	0.52

Finally, the control group's results are shown in Table 6. For this group, there is no statistically significant difference between the pre- and post-test results

under any of the conditions. As a result, in subsequent studies, the Control Group is used as the baseline data group.

Table 6: Pre and post-test difference in Group E

	Z	p
V1PreT1T-V1PostT1T	1.904	.057
V1PreT2T-V1PostT2T	1.033	.302
V2PreT1T-V2PostT1T	.099	.922
V2PreT2T-V2PostT2T	.000	1.000
V3PreT1T-V3PostT1T	.204	.838
V3PreT2T-V3PostT2T	.081	.935

The Kruskal-Wallis test was used to compare the gain scores of Videos 1, 2, and 3 in the receptive and productive knowledge exams in order to address Research Question 2 (RQ 2).

Across all five groups ($n = 115$), the analysis showed statistically significant differences in the receptive knowledge of Video 1 ($\chi^2(4, n = 115) = 45.13, p < .001$). A statistical analysis using post-hoc pairwise comparisons reveals significant differences between the Control group and the groups that watched movies with subtitles just once ($p = .002$), twice ($p = .000$), and twice without subtitles ($p = .000$). The results of the studies also reveal a statistically significant difference between the groups that watched videos without subtitles once and twice ($p = .011$), twice ($p = .02$), and once ($p = .002$). Comparing any other groups revealed no statistically significant differences. However, the statistical analysis of productive knowledge of Video 1 across five distinct groups ($n = 115$) does not reveal a significant difference ($\chi^2(4, n = 115) = 5.14, p = .238$).

The study shows that there is a statistically significant difference in the receptive knowledge of Video 2 among the five groups ($n = 115$), with $\chi^2(4, n = 115) = 13.13, p < .011$. A statistically significant difference ($p = .012$) was seen between the Control group and those who watched movies twice with subtitles, according to post-hoc pairwise comparisons. In all other group comparisons, no statistically significant differences were found.

Additionally, the analysis showed a statistically significant difference in each group's productive knowledge of video 2 ($n = 115$); $\chi^2(4, n = 115) = 16.81, p = .002$. A statistically significant difference was seen between the control group and the group that viewed films twice with subtitles, according to post-hoc pairwise comparisons ($p = .002$). Statistics did not show any statistically significant differences in any of the other group comparisons.

The investigation also showed that there was a statistically significant variation in the five groups' receptive knowledge of video 3 ($n = 115$); $\chi^2(4, n = 115) = 21.4, p < .001$. A statistically significant difference was observed between the Control group and the individuals who viewed the movies once ($p = .007$), twice ($p = .010$), and twice ($p = .001$) without subtitles. These differences were found using post-hoc pairwise comparisons. Statistics did not show any statistically significant differences in any of the other group comparisons.

A statistically significant variation in the productive knowledge of Video 3 was also found across the five groups ($n = 115$); $\chi^2(4, n = 115) = 26.71, p < .001$. Subsequent post-hoc pairwise analyses demonstrated a statistically significant difference ($p = .000$) between the Control group and the individuals who viewed movies twice, one with subtitles and the other without ($p = .000$). Statistics did not show any statistically significant differences in any of the other group comparisons.

IV. DISCUSSION

According to the findings of the study, the participants who watched the videos with subtitles on all three occasions (Videos 1, 2, and 3) increased their receptive vocabulary knowledge and those who watched videos without subtitles twice were also able to increase their receptive vocabulary knowledge compared to the Control group in Videos 1 and 3. The participants who watched a video for the first time either with or without subtitles did not show any difference in productive vocabulary knowledge and those who watched videos for the second or third time with subtitles twice increased their productive vocabulary knowledge in comparison to the Control group. Those who watched the third video twice without subtitles also demonstrated productive vocabulary knowledge gains.

The findings of this study is linked with the findings of the studies conducted by Ahmad and Zahra (2022), Winke et al. (2010), Madhubala et al. (2010), Ebrahimi and Bazaee (2016), and Bellalem et al. (2018) Malek Ahmad Kord, Najmeh Arab Goorehooyi, and Zahra Mohammadi Dehaj (2022), Rosmia Citra Lestari (2018), Ayand and Shafiee (2016) to examine the impact of audio videos materials with and without subtitles on vocabulary learning among undergraduates because all these studies consistently demonstrate a positive impact of using subtitled videos on vocabulary acquisition.

V. CONCLUSION AND IMPLICATIONS

The overall results indicate that watching videos with subtitles once is sufficient for acquiring receptive vocabulary knowledge and watching videos without subtitles multiple times may also increase receptive knowledge. But, for productive knowledge gains, learners may have to watch videos with subtitles multiple times. In considering the research findings, it can be concluded that

watching subtitled videos not only aids in acquiring new vocabulary but also significantly enhances learners' ability to use the acquired vocabulary productively in spoken or written language.

Finally, following implications can be concluded from this study.

1. Technology-based learning tools, namely computers, multimedia projectors and audio video software are recommended to apply in the second language teaching
2. As sub-titled videos can greatly facilitate second language vocabulary learning, second language practitioners can apply these authentic materials in ESL classrooms.
3. The qualitative data of the study also revealed that participants generally have a positive attitude in watching sub-titled videos, this technique can be used to enhance the motivation of the learners to learn English
4. The findings of this study indicate a significant effect for ESL/EFL teaching mainly for young learners. Therefore, this strategy can be highly recommended for adult learners
5. Further, the visual and auditory input of subtitled videos can create a very rich learning environment in an ESL classroom. Therefore, ESL teachers can use this strategy to create a more interactive learning environment in their classrooms.

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**BALANCING ACADEMIC AND PROFESSIONAL
RESPONSIBILITIES: AN EXPLORATION OF STRESS FACTORS
AMONG FULL-TIME WORKING UNDERGRADUATES AT
GENERAL SIR JOHN KOTELAWALA DEFENCE UNIVERSITY,
SRI LANKA**

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Abstract - This study examines multiple stressors affecting undergraduate students balancing full-time employment with academic commitments. Using an exploratory, qualitative methodology, the research examines the academic, personal, socio-cultural and economic stressors experienced by students enrolled in the weekend BSc management programme at General Sir John Kotalawala Defence University. The study's data collection included nine semi-structured interviews, and purposive sampling was used to gain a deeper understanding of the lived experiences of these students. Theoretical frameworks by Selye and Folkman underlie the study, highlighting stress as a physiological and cognitive response to various demands. The purpose of this study is to identify specific stressors, their impact on students' academic success rates and current mental health and coping strategies of mentioned undergraduates. These findings are useful in formulating institutional policies and service support to eliminate stress and enhance overall performance of students. Therefore, ~~to observe~~ the implications of the study are as follows: the results of the study are useful to educational institutions, managers, industries and policy makers. In addition, the research contributes to the broader discourse on student mental health, particularly in the context of full-time working professionals studying higher education. Regardless of its contributions, the study acknowledges the inherent limitations of qualitative research and by addressing these limitations, the research aims to provide a solid foundation for future studies and practical applications to improve the academic and professional experiences of working undergraduates.

Key words: coping strategies, psychological wellbeing, stress factors

I. INTRODUCTION

This study investigates the stressors affecting KDU's BSc Management Weekend Program undergraduates, who

must balance a professional life with academic work. Due to KDU's education system, which includes a military-like system and discipline along with high academic standards, the challenges are different. The target students are often working students who study only on weekends and ~~work~~ have full-time work schedules five days a week. Here the students are again under pressure to balance the opportunities. Because the schedule presented here does not allow enough time for leisure and personal activities, which strongly contributes to chronic stress. Academic stress, which can be acute or chronic, proves to be a psychological and physical disease that causes anxiety, depression, and burnout among students, thus reducing their class performance and overall quality of life.

The importance of this study is based on the emerging concern about mental health in learning institutions and the escalation rates of student stress. The researcher is trying to find the answers for the gaps such as knowledge gap, practice gap and empirical gap. It was identified the knowledge gap where there is insufficient understanding of the factors influencing the psychological well-being of university undergraduates. This includes social, academic, environmental, and personal factors and the nuanced relationships between these factors and their impact on well-being. In practice gap, the attempt is to investigate whether evidence-based support services and interventions for enhancing psychological well-being are effectively implemented within university settings. Further through the empirical gap it is identifying the lack of comprehensive quantitative and qualitative data on the factors influencing the psychological well-being of university undergraduates.

This research is both relevant and urgent as it seeks to gather data that will help shape the university's position and practices. Understanding the sources of stress and finding effective preventative measures and ways to alleviate it can help to better organize the learning environment, increase student satisfaction rates, and thus contribute to higher retention and success statistics. The results of the study will spread knowledge about stress among students, especially those studying while working. This could open the door to improving and enhancing policies for the psychological and emotional welfare of academics worldwide.

11. PROBLEM STATEMENT

Undergraduates who attend university and work fulltime as professional workers face significant and unique academic and professional pressures, balancing both majoring and important professional commitments. Learning stress, defined by (Ross, et al., 1999) arises from factors such as high academic workload, poor time management, and poor performance. Similarly, the Public Agency for Occupational Safety and Health states that work-related stress is an adverse psychological and physical development resulting from the interaction between the individual and job demands. This reduces the risk of developing serious physical, mental and emotional diseases such as anxiety, mental disorders, conception and poor results in study and work life. However, there is **an award of a significant number of literature** that specifically focuses on student stress factors among full-time students in higher education institutions. The purpose of this thesis is to find and pinpoint differences in independent study and work-related stress among these students and the strategies they use to cope with stress. Thus, the study aims to identify specific strategies and intervention programs to update the quality of life, academic achievement and labor monitoring of these individuals. Also, advertising to educational

organizations and legislators to develop the support of these students. This research adopted the framework used by (Selye, 195) and (Folkman, 1894) to determine stressors in order to find out the factors and coping strategies among university undergraduates who are also working employees.

11.1. RESEARCH OBJECTIVES

To investigate how academic and work-related stressors interact to impact the mental well-being and academic performance of full-time working undergraduate ~~university~~ students.

To identify the key risk factors that contribute to anxiety and depression among full-time working undergraduate ~~university~~ students.

To explore the demographic characteristics (e.g., age, gender, employment details) of full-time working undergraduate ~~university~~ students.

To examine how work-related factors contribute to stress among full-time working undergraduate ~~university~~ students.

To determine the extent to which academic stressors influence stress levels among full-time working undergraduate ~~university~~ students.

To examine how the balance between work and academic commitments affect stress levels among fulltime working

undergraduate university students.

To assess the willingness of full-time working undergraduate university students to seek professional help or support for mental health issues.

To propose practical recommendations for support services, interventions, or policies aimed at enhancing the mental well-being of full-time working undergraduate university students.

IV. LITERATURE REVIEW

Academic stress is understood as a psychological fact caused by academic and social pressures (Misra, et al., 2000) It's a complex conception that includes numerous factors emotional, social, and academic stressors (Misra & McKean, 2000) Experimenters have measured academic stress in numerous aspects such similar as academic pressure, workload, worry about grades, boredom and self-expectation (Sun, et al., 2011), numerous factors have been linked as having an impact, related to scholars' academic stress academic workload, money difficulties, fear of failure (Aihie & Ohanaka, 2019) lecturers' tutoring actions and styles (Trigueros, et al., 2020) difficulties in class, high prospects, test anxiety, bullying, social comparison, poor connections with friends, domestic violence (Aiman, et

al., 2020). Academic stress has a huge impact on scholars' academic performance, psychological health, psychological well-being, quality of life, and indeed absenteeism. Exploration by (Tus, 2020) and (Rehman, et al., 2023) confirm that academic stress has a negative impact on scholars' academic performance, scholars with high situations of stress frequently have poorer academic results than other scholars. Stress and other psychological health issues can negatively impact the health of university undergraduates (Wyatt & Sara B. , 2012) being significantly identified with mental well-being (Barbayannis, et al., 2022) and has a negative association with quality of life. Exploration by authors (Marôco, et al., 2020) , (Noman, et al., 2021) confirms that academic stress is one of the causes leading to students missing academy. Effectively managing with stress is important in perfecting scholars' mental health, quality of life, and academic achievement. Thus, paying attention to and supporting scholars to effectively manage with academic stress is very important. (Van, 2023) Studies state that job related stress is an antecedent of job satisfaction that leads to job performance and development intention. (ruyter, et al., 2002) Job role stress is defined as the stress a hand experience when organizational requirements and individual requirements don't align (Bano, et al., 2011).

Studies shows that the workers who are exposed to job stress for a longer period have more tendency to get burnt- out, dropped overall performance and it also the morale among co-workers in a negative way (Band, et al., 2016). Also, longer exposures to organizational job role stress may also lead to dropping the quality of services and products, poor customer connections, a dysfunctional work climate and high labour development (Bano, et al., 2011). Job role stressors or the causes of job role stress are hugely ineluctable in nature and have become a major concern at the plant. Number of studies can be set up that there's a positive relationship between job role stressors and job stress that would directly impact the hand performance negatively (Trayambak, et al., 2012). Fairly, enquiries have been set up that lower position workers are subordinated to further stress than top position workers (Chandola, et al., 2018)

V. THEORATICAL FRAMEWORK

In the planned study on stress factors among undergraduate scholars who work and pay focus on studies and their academic liabilities, the transactional model of stress and managing by (Lazarus & Folkman, 1984) would be appropriate. Not clear This paper looks at the mobility of the stress appraisal and stress management process which captures the essence of the manner in which scholars

handle what they consider to be the binary stressors of academic and professional responsibilities. This model was selected due to the following characteristics it has: Focus on stress and coping, Emphasis on cognitive appraisal, identifying various stress factors, and integration of managing strategies, and this model is a validated framework in the field of psychology.

VI. POPULATION AND SAMPLE

The population, the target group is the full-time working undergraduates in BSc in Management – 16th intake of the General Sir John Kotelawala Defence University. Convenience sampling was applied to reach the participants. In BSc in Management – 16th intake of the General Sir John Kotelawala Defense University- there were twenty students who are processing in various sectors such as tri forces, government and private sector. Considering the demographic factors such as age, gender, and marital status, the samples base consisted of all the varieties. The sample was only ten students which was 50% of the population.

VII. DATA COLLECTION

For the purpose of this study, initially emails were sent to the participants explaining the nature of the study, and a brief about the expectations from the participant expecting them to agree to a zoom interview and

asking them about their availability for the interview. While conducting the interviews 'why' and 'how' questions were asked from the participants so as to get proper and real-life experiences. Furthermore, since a strict script was not followed, while conducting the interviews, additional questions were asked from the respondents based on their answers given, which are also not included in the template. The recorded sessions were transcribed with the help of Turboscribe and Otter.AI Voice transcribing software. Initially the plan was to obtain from the sample base of ten participants however when collecting data, it was noted that the data was being saturated.

VII. DATA ANALYSIS

The analysis will encompass several techniques including thematic and content analysis approaches to summarize the main key facts of the collective data. Thematic analysis examines qualitative independent variables and dependent variables. Content analysis examines several key factors in the content of interview transcripts.

Thematic Analysis

Thematic analysis was used to search for patterned themes or patterns consistently revealed across the interview transcripts (Braun & Clarke, 2006). Through this method, several key themes emerged. As per the above table four themes were

identified which will be useful in further analysis. Subthemes were constructed by the researcher by reading transcripts line by line and identifying what participants were trying to disclose. Likewise, they are grouped into a common category and developed themes as shown. The evidence from the participants was grouped under the identified themes as shown in Table 4.3. The researcher used the following (P1-P9) to represent the 9 respondents for the easiness of the data presentation, as depicted in the table.

Researcher could find illustrative evidences for the primary themes.

Academic Stress

P1 - "Sometimes in exam periods, ~~they introduce~~, they announce an exam within a short time period."

P2-"So I have to work after the lectures, and it is very hard to allocate and spare time to do my proper education within the campus."

P4-"Sometimes we are not getting the exam schedule before one month prior. "

P5-"Because that makes it like the work, bloat and the study factors making it hard to stay focused during lectures or when studying after work." Does not make sense

Work-related Stress

P1 - "previously when when I joined that company, there were

four members. But in present, there are two members. So we have to do a lot of work.", "our bosses are very aggressive and they always trying to make conflicts within us.", "Workload and management stress and some other conflicts between some departments." (not very clear)

P2 - "I can't manage this academic situation with my job situation."

P3-"Sometimes we have to work for 24 hours without any rest time."

P4 - "So we have to manage the time and during the exam, we have to take leaves. It's very hard to get approvals from the management division."

Personal Challenges

P8-"I am the only person who has come so far from Jaffna to Colombo by bus and stayed in a circuit bungalow near the KDU. So, my stress is travelling only. It was more than seven hours traveling.", "I can't manage in Sinhala. There is a language problem, I can manage English.", "I don't have that much money, I am only facing the expense problem, otherwise no issue."

Coping Strategies

P1-"When I am in a stressful situation, I always chat with my best friend". "Especially my parents are helpful in doing my academic activities and I have a very good friend."

P3-"So I take some support from my colleagues and also

my friends in campus. So they gave me good support with their busy schedules. "

P4-"I play with my pet and I talk to my friends and I talk to my mom." "I'm watching movies.", "I talk to my friends and tell them my issues and get help from them."

P5-listening to slow, slow motion music, and after that, I'm just writing in a diary or whatever the thing, or if I don't have a book or something like that, I'm just writing in the notepad like that"

P7-"There are some other ways, like listening to music or staying in a calm and quiet environment. So, I'm following that."

Source: Developed by the Author (2024)

As shown above, each of the themes is supported by an example that is quoted from the answers given by the participants in the interview they had with them. As shown in the above, there is a variety of answers given by the participants on similar themes.

Content Analysis

In this study, the approach used was content analysis which addressed the structural dimensions and content details of the interview transcripts as the data was collected. This method involved:

Identifying Key Terms and Concepts

Examining Contextual Factors

Comparing and Contrasting Perspectives

VIII. RESULTS

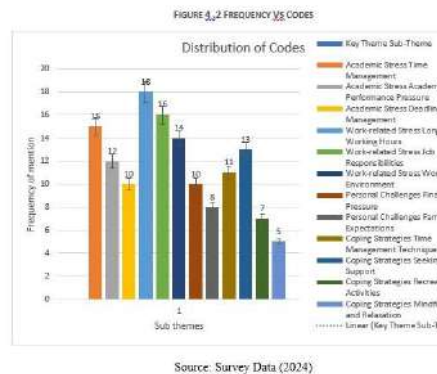
Four key themes were found from the thematic analysis. They are academic stress, work related stress, personal challenges and coping strategies. Sub themes were developed according to the main four themes. According to the ideas that were expressed by the participants, the majority of participants mentioned that the work-related stress factors were long working hours, job responsibilities and the work environment. Among them the most significant work related stress factor is long working hours which has a frequency of 18 mentions by the participants. The second most significant key theme is coping strategies and participants spoke about it under four sub key themes such as time management techniques, seeking social support, recreational activities and mindfulness and relaxation. Next participants mentioned academic stress factors which have a greater contribution than personal challenges. They spoke about academic stress factors under three sub themes; time management, academic performance pressure and deadline management. Among them students mentioned time management issues with a frequency of 15 times. Some students had personal challenges such as financial pressures and family expectations as stress related factors when balancing the

student worker roles. According to the word map schedule and time concerns have been major factors. By analyzing the content it was found that there are a few main contents in the interview transcripts commonly. Researchers found that participants had used universal labels of key terms and concepts related to psychology. Since the participants has shared their personal experiences related to work and academic related content, the researcher could identify some contextual factors behind academic and work related stress. Further looking at the participants' various kinds of experiences, the researcher found that they can be compared due to their demographic differentiations.

FIGURE 4.1 WORD MAP



FIGURE 4.2 FREQUENCY VS CODES



IX. DISCUSSION

According to the interview information, the following findings were obtained related to the research objectives.

1. The findings revealed that students are getting both work and academic stress while working full time and studying during part time. Also, it was noted that students are less performing both academically and in their careers when they are being stressed.

2. Students have mentioned that both academic and work related factors are being impacted by the stress, and the major contribution is from work-related factors.

3. When discussing the demographic factors among the 9 participants of the sample base, most of these are male participants. Also, there were five married participants who can obtain the support of the spouse. Among these participants' most of them do not have children. However, most of the participants are finding it difficult to manage

the time to spend with their families. Majority are in the 35-40 age group which have both official and family commitments. When considering the job roles government sector participants are higher than the private and semi sectors.

4. As for the burdens identified by many participants, aspects such as working hours, job description, weaknesses of management and the general working conditions. Participants explained how these factors influenced the stress received as well as the level of concentration on academic work.

5. A number of participants also mentioned concerns with balancing tasks relating to academic stress. Some of the problems included conflicts between class attendance and working, being able to meet class due dates, and the general pressure to achieve in academics.

6. Most of the students are currently unable to balance the careers and academic lives equally.

7. The findings showed that there was a high position of hesitancy among scholars to consult a professional in case of internal health issues. Similar hesitance is primarily a result of prejudice, lack of awareness of what services are available, and insufficiency of the services offered. It thus becomes more frustrating that the internal health of full-time working scholars doesn't have effective

support systems created and enforced by the universities and employers, similar systems being responsible, considerate and nonpublic.

8. Recommendations were suggested to enhance the collaboration and programme structure, move to online or hybrid sessions, implement support mechanisms in both companies and universities and implement regular feedback mechanisms.

X. CONCLUSION

In line with the interviews conducted on full-time working undergraduates of KDU, this study presents variety of academic, work-related, specific, and contextual stressors that negatively affect the students' mental health. Qualitative data analysis includes thematic analysis including the stress of balancing study with work, stress management, and stress related to social problems and substance issues and content analysis of the factors that produce structural or contextual stressors. The results show several significant independent factors contributing to day scholars' stress, along with the theoretical benefactions and the practical guidelines for enhancing and developing the internal health services in similar educational and occupational surroundings. This study reveals that there's a severe relationship between the academic and work-related stressors that negatively impacts the mental health and

performance of full-time working undergraduate university students. It confirms the direction of the advanced learning institutions in a support to strengthen students' mental wellbeing and increase the inflexibility of the delivery of educational services. Also, understanding that the scholar's roles in two kinds of polity in their position as learners and workers, employers should perform certain organizational functions like workload regulation and stress regulation. In order to manage these multifaceted issues efficiently, it's imperative not only for the improvement of the education quality but also for the students' mental health throughout their academic and career quests.

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Leveraging Artificial Intelligence for Human Resource Management: A Bibliometric Analysis

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Abstract – This study aims to identify the primary topics and present dynamics in the field of Artificial Intelligence (AI) and Human Resource Management (HRM) and to make recommendations for improving the HRM mechanism integrating AI. A bibliometric analysis was conducted on a selection of 505 studies from the Web of Science database to determine the extent of research on AI and HRM from 1996 and 2024. In this study, researchers identify the most influential articles and writers based on their citations, publications, and geographical locations. Additionally, how they assess existing themes, identify concerns for growth in the literature, and recommend future study options. This study has seven objectives relating to AI and HRM; determine the trend of articles on AI and HRM; determine which pioneer authors on the subject of AI and HRM are most frequently mentioned; determine which sources (including journals) are leading in the fields of AI and HRM; examine the international distribution; find the pertinent author keywords for AI and HRM; analyze the highest cited articles; identify the research gaps in the area of AI and HRM for future studies. The Literature Review was carried out by examining highly cited relevant articles from the Web of Science. The bibliometric analysis unearthed two main research gaps. Lastly, we conclude by proposing future studies and recommendations.

Keywords: Artificial Intelligence (AI), Bibliometric Analysis, Human Resource Management (HRM), Leverage

I. INTRODUCTION

Human Resource Management (HRM) is the strategic use of an organization's most valuable resource to achieve its objectives. (Opatha, 2019). Therefore, HRM mainly includes all aspects of people management to accomplish desired organizational goals. Jabbour and Santos (2008) highlight the need to integrate sustainability with human resource systems since it helps HRM

create sustainable organizations. The integration of HRM principles with organizational objectives for environmental sustainability is known as 'Green HRM' (Iddagoda et al., 2020). According to Renwick et al., (2013), green HRM is the HRM facet of environment management. Janadari and Ekanayake (2021) state that organizations endeavour harder than ever to be more environmentally friendly and they have commenced attempting to positively influence employees' thoughts on the subject. The engagement of employees is a creation of both behaviour and attitude (Iddagoda et al., 2016). Artificial Intelligence (AI) has the potential to enhance talent management strategies through the deployment of sophisticated automated workforce management systems (Faqihi and Miah, 2023). The application of artificial intelligence (AI) in human resource management (HRM) is growing because of its potential to benefit customers, employees, and businesses (Chowdhury et al., 2023).

1) *Research gap:* There is a dearth of studies related to the review of AI and HRM.

2) *Research objectives:* This study has seven objectives. The first objective is to determine the trend of articles on AI and HRM. The second is to determine which pioneer authors on the subject of AI and HRM are most frequently mentioned. The third is to determine which sources (including journals) are leading in the fields of AI and HRM. The fourth objective is to examine the international distribution. Finding the pertinent author keywords for AI and HRM is the fifth research objective. The sixth objective is to analyze the highest cited articles. The seventh research objective is to identify the research gaps in the area of AI and HRM for future studies.

II. MATERIALS AND METHODOLOGY

A) Explanations

To give a comprehensive picture of the present state of scientific production and assess the caliber of

earlier studies, bibliometric analysis was employed in this paper to provide a wealth of data on a particular subject. From 1998 to 2017 and even beyond, bibliometric analysis has expanded at an even faster rate (White and McCain, 1998; van Eck and Waltman, 2017). This method, as explained by statisticians and mathematicians (Garfield, 1955), makes use of a variety of mathematical instruments and statistical approaches to analyze and survey published works, including books and articles. Statistical methods illustrate scientific research explanations and disciplinary arrays (De Bakker et al., 2005; Bouyssou and Marchant, 2011). Bibliometric analyses inform researchers about the history of a field, illuminate its current state, and propose new research directions (Durieux and Gevenois, 2010; Bilal et al., 2022). According to Dissanayake et al., (2022), the following are the five stages in a typical bibliometric analysis; search database, search criteria, inclusion criteria, data analysis, data visualization and interpretation.

Search Database	Web of Science
Search Criteria	“Artificial Intelligence (AI)” and “Human Resource Management (HRM)” - 505 articles
Inclusion Criteria	Original English Journal Articles - 274
Data Analysis	Trend Analysis •Journal Analysis •Country Analysis •Keyword Analysis •Author Analysis
Data Visualisation and	Trend Graph •Top authors’ production over

Interpretation	time graph •Corresponding author country map •Word Cloud •Thematic Map
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B) Search Database

When it comes to scientific literature, the Web of Science is recognized as the largest and most inclusive database in existence. More than 10,000 peer-reviewed, high-impact academic journals covering the life and physical sciences, medicine, technology, and other related disciplines are included. The Web of Science database was used for the research in this study.

C) Search Criteria

This study used “Artificial Intelligence” and “Human Resource Management” as search terms in the Web of Science database. Initially, 505 documents were extracted.

D) Inclusion Criteria

Next, non-English language articles and non-journal publications were removed to obtain a better review. Finally, researchers analyzed 307 English language journal publications. Out of that; there were 274 journal articles, 01 book chapter, 29 early access articles, 01 proceedings paper, and 02 retracted publications. Finally, this study selected 274 articles for further analysis.

E) Data Analysis

In this paper, researchers used the Biblioshiny program to examine and depict the current state and future directions of entrepreneurship education in university research. Massimo Aria created the Biblioshiny software with the Shiny package written in the R programming language (Aria and Cuccurullo, 2017). Next, this study used bibliometric analysis techniques to explore the trend of publications, source analysis, country analysis, author analysis and keyword analysis. The authors’ journal productivity is analyzed using h-index, g-index, m-index and total citations.

The h-index is a non-dimensional measure of an author's scholarly influence based on the frequency with which their work has been cited by other scholars in the field. According to the definition of the h-index provided by Bornmann and Daniel (2007) and Choudhri et al., (2015), an h-index author has published at least h articles that have been cited at least h times. Similar to the h-index, the m-quotient (or m-index) is calculated by dividing an author's h-index by the number of years since their first publication. The g-index is the middle value of the number of citations (or the frequency with which an article has been referenced) for the top 'g' articles.

F) Data Visualisation and Interpretation

Lastly, data is visualized using tables and figures including trend graph, top authors' production over time graph, corresponding author country map, word cloud and thematic map. Subsequently, these tables and figures are interpreted to derive meaningful conclusions.

III. RESULTS

This section explains trend analysis, author analysis, source analysis, country analysis, keyword occurrence analysis, highest cited articles analysis and research gaps.

A) Trend Analysis

This study used time series analysis and stages of development analysis to explain the evolution of trends in AI and HRM. A time series analysis allows for a year-by-year look at the evolution of development by the overall situation, and research trends are reflected in the yearly distribution of documents. Next, the articles can be broken down into discrete phases, and the features of the overall trend are displayed through the description of various stages of development. For the analysis of the articles, 10-year periods were used (1996–2005, 2006–2015 and 2016–2024).

From 1996 to 2005 maximum of one publication was recorded and in some years not even one was published. Similarly, from 2006 to 2015 a similar pattern was observed with a maximum of two publications in the years 2011, 2014 and 2015. A very significant increase of publications was observed from 2016 to 2024 to date. The year 2023 recorded the highest number of publications with 87 and 70 publications up to date in 2024, 70

Author	h_index	g_index	m_index	TC	NP	PY_start
BUDHWAR P	5	6	1.66666667	157	6	2022
MALIK A	5	9	1.66666667	160	9	2022
ATHAMANOLAP P	4	5	0.36363636	193	5	2014
CARLSON DA	4	6	1	46	7	2021
KOU WJ	4	6	1	46	7	2021
PANDOLFINO JE	4	6	1	46	7	2021
WANG TH	4	5	0.36363636	190	5	2014
YANG S	4	4	0.36363636	190	4	2014
BAUMANN AJ	3	3	0.75	40	3	2021
ETEMADI M	3	4	0.75	30	4	2021
FRALEY SI	3	5	0.27272727	102	5	2014
KUMAR S	3	3	1	21	3	2022
ROZMAN M	3	3	1	16	3	2022
TOMINC P	3	3	1	16	3	2022

publications. Figure 1 illustrates the periods 1996–2005, 2006–2015, and 2016–2024.

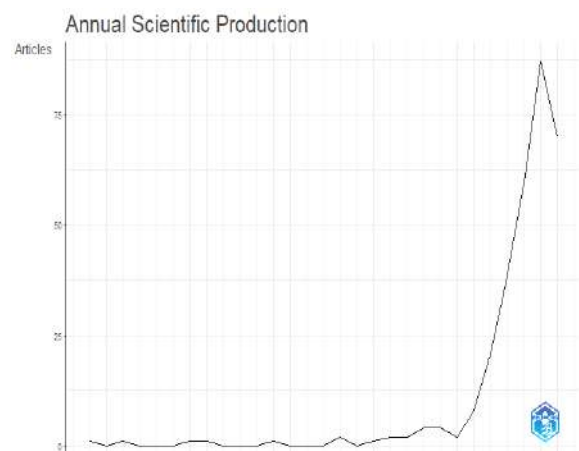


Fig 1. The Annual Scientific Production (1996 to 2024)

B) Author Analysis

There were a total of 1013 authors in

Source	h_ index	g_ index	m_ index	TC	NP	PY _start
HUMAN RESOURCE MANAGEMENT REVIEW	8	9	2	320	9	2021
INTERNATIONAL JOURNAL OF HUMAN RESOURCE MANAGEMENT	5	6	1.6666 6	207	6	2022
INTERNATIONAL JOURNAL OF MANPOWER	5	5	1.6666 6	112	5	2022
JOURNAL OF INNOVATION & KNOWLEDGE	4	4	1.3333	64	4	2022
SUSTAINABILITY	4	6	0.8	42	10	2020
ANALYTICAL CHEMISTRY	3	3	0.375	126	3	2017
HUMAN RESOURCE MANAGEMENT	3	4	0.75	112	4	2021
HUMANITIES & SOCIAL SCIENCES COMMUNICATIONS	3	3	1.5	10	4	2023
INTERNATIONAL JOURNAL OF ORGANIZATIONAL ANALYSIS	3	6	0.75	38	7	2021
PLOS ONE	3	4	0.2727	52	4	2014

the study, with 30 contributing one paper. Table 1 shows that Athamanolap P, Wang TH and Yang S are the highest-cited authors who received more than 180 citations. Budhwar P has an h-index of 5, a g-index of 6, and a total citation count of 157. Malika A has an h-index of 5, a g-index of 9, and a total citation count of 160.

Table 1. Authors

Source: Constructed based on Biblioshiny Software

C) Source Analysis

Table 2 shows the most relevant journals. The Human Resource Management Review Journal is the highest cited journal with 320 citations. The journal has an h-index, g-index, m-index of 8, 9 and 2 respectively.

Table 2. Most Relevant Journals

Source: Constructed based on Biblioshiny Software

D) International Distribution

It is possible that a country's prominence and sway in the study of AI and HRM can be assessed by the number of papers published there on a particular topic. USA has the highest number of total citations with 681 during the period with 13.9 average article citations (Table 3). Finland possesses the highest average article citations 24.6.

Table 3. Country Analysis

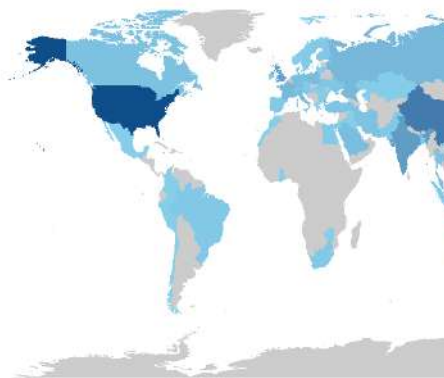
Country	TC	Average Article Citations
USA	681	13.9
AUSTRALIA	295	19.7
CHINA	280	5.4
FRANCE	267	19.1
UNITED KINGDOM	247	17.6
INDIA	182	7.3
GERMANY	158	13.2
ITALY	140	15.6
FINLAND	123	24.6
POLAND	87	10.9

Source: Constructed based on Biblioshiny Software

Table 4 and Figure 2 demonstrate the countries' scientific production. It depicts that the USA is dominating with China in the second and India in the third place.

Region	Freq
USA	179
CHINA	113
INDIA	65
UK	57
AUSTRALIA	32
RUSSIA	29
FRANCE	28
ITALY	26
POLAND	24
SOUTH KOREA	22
GERMANY	21

Country Scientific Production



E) Keyword Occurrence Analysis

Table 5. Keywords Occurrence Analysis

Words	Occurrences
artificial intelligence	110
human resource management	72
machine learning	47
artificial intelligence (AI)	12
AI	10
human resource management (HRM)	9
human resources	9
talent management	9
Technology	9
Digitalization	8
employee engagement	8
human resources management	8
big data	7
Ethics	7
HR analytics	7
HRM	7
Recruitment	7
Sustainability	7
Innovation	6
e-HRM	5

Word Cloud is exemplified in Fig 3. Accordingly, the most used word is ‘artificial intelligence’.



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F) Analysis of Highest Cited Articles

The Internet of Things and artificial intelligence (AI) are two examples of the smart technologies brought about by the Fourth Industrial Revolution (Schwab, 2016). The way resources are arranged and distributed inside organizations is altered by the integration of AI (Xu et al., 2020). Recent studies have found that organizations are yet to experience the projected benefits of AI adoption, despite investing time, effort, and resources (Chowdhury et al., 2023). Kong et al., (2020) state the extensiveness of artificial intelligence (AI) has noticeably affected management and society. Kong et al., (2020) found a positive relationship between AI awareness and job burnout and no significant direct relationship between AI awareness and career capabilities. Further, has found organizational commitment mediated the relationship between AI awareness and career competencies, as well as the relationship between AI awareness and job burnout. Esch et al., (2019) highlight that organizations are commencing to adopt and exploit the functionality of AI in their recruitment processes. Further, Esch et al., (2019) found that the attitudes towards organizations that use AI in the recruitment process significantly influence the likelihood that latent candidates will complete the application process. Pan et al., (2023) stress that the AI has been presented as a dominant tool in human resource management (HRM), but less academic research exists on the topic. Pillai and Sivathanu (2020) found that cost-effectiveness, relative advantage, top management will, HR enthusiasm, competitive pressure, and support from AI vendors positively affect AI technology implementation for talent acquisition. Trocin et al., (2021) highlight that AI is igniting a new breed of digital innovation in Human Resource Management (HRM) by generating new opportunities for conforming with the General Data Protection Regulation (GDPR) during data collection and analysis, decreasing biases, and offering

directed recommendations. AI is also posing challenges to organizations and crucial assumptions about digital innovation methods and outcomes, making it vague how to combine AI affordances with actors, goals, and tasks (Trocin et al., 2021). Malik et al., (2023) found that the usage of AI-enabled bots, virtual, digital, and personal assistants for carrying out a range of HRM tasks, such as routine, analytical, interactional, and communicative tasks involving employees. Oswald et al., (2020) highlight that big data and AI have become fairly compelling and pertinent, ideally to organizations and the consulting services that help manage them. Human workers' task fulfillment expectations with their AI-enabled robot colleagues need to be sensibly communicated and managed by HRM staff to maintain the collaborative spirit, as well as future performance evaluations of employees (Arslan et al., 2020). Kim et al., (2021) found that several developments are prominent in research on the impact of technology on jobs and organizations.

G) Research Gaps

The 'Thematic Map' is illustrated in Fig 4. Accordingly, the 'Motor Themes' that is with the highest 'relevance degree' (X axis) and the highest 'development degree' (Y axis). It indicates talent acquisition, adoption and recruitment as the most trending. 'Basic Themes' are with a high 'relevance degree' and a low 'development degree'. It indicates AI, HRM and employee turnover. 'Niche Themes' with a high 'development degree' and low 'relevance degree'. It indicates sustainable hr, deep learning, bias and hr system. 'Emerging or Declining Themes' are with a low 'relevance degree' and a low 'development degree'. It indicates algorithmic management.

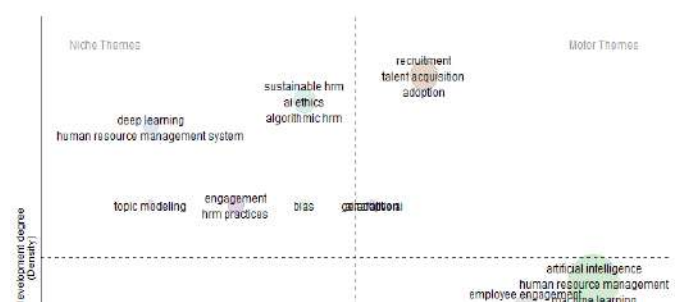


Figure 4. Thematic Map

Accordingly, the following are the identified research gaps fulfilling the seventh research objective.

Gap 1: There is no empirical evidence about the relationship between AI and talent acquisition.

Gap 2: There is no empirical evidence about the relationship between AI and HRM in the Sri Lanka Navy context.

IV. DISCUSSION, LIMITATIONS AND CONCLUSION

A) Discussion

The bibliometric analysis using quantitative and qualitative analysis of highly cited documents reveals two main research gaps and future recommendations for leveraging AI in Human Resource Management (HRM). There is no empirical evidence about the relationship between AI and talent acquisition is one main gap. The other gap is that there is no empirical evidence about the relationship between AI and HRM in the Sri Lanka Navy context. To evaluate the long-term advantages and difficulties of integrating AI into military HRM, future research should concentrate on creating strong frameworks for AI-driven HRM and investigating the ethical implications of AI deployment.

B) Limitations and Further Studies

The bibliometric analysis was limited to the Web of Science database and conducted only from 1996 to 2024. Future studies can focus on bridging the identified research gaps.

C) Conclusion

AI has the potential to improve HRM strategies mainly for recruitment, and talent acquisition, and thereby increase organizational agility. Therefore, by bridging the identified research gaps, a suitable mechanism can be designed and developed to achieve the Sri Lanka Navy's desired objectives.

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Do Data Science Degrees in Sri Lanka Fullfil the Needs of the Job Market?

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Abstract— This study has investigated the alignment between the contents of data science undergraduate degree programmes and the data science job market prerequisites in Sri Lanka. The analysis focused on identifying the fundamental elements of these degree programmes and the skills needed for different data science career positions. The study utilised document analysis method to analyse the contents of curricular of 10 degree programmes and 15 job descriptions. Frequency and thematic analyses were used to identify patterns of curricular contents and job competencies. The findings

suggest that although the majority of degree programmes prioritise the development of programming and statistical competencies, they frequently neglect to provide hands-on experience with essential tools such as Power BI, SQL, and cloud technologies required by the job market. This discrepancy indicates a requirement for improving the curricular in order to more effectively equip graduates for the demands of the industry. The results of our research offer insights to educational institutions on how data science

degrees should be developed/revised based on industry requirements.

Keywords— Data science, degree programs, skills

I. INTRODUCTION

Data science encompasses mere collecting, storing, analyzing, and extracting insights from data and involves techniques such as data mining, online analytical processing, artificial intelligence, machine learning, and decision science to make reliable predictions about future. These help institutions to make informed decisions in a fast-paced and competitive business environment (Kumar & Aithal, 2020).

According to Drew (2022) and Gulati (2024), the most common data science roles are:

- Data Engineer / Data Architect: developing the cloud infrastructure to house the data
- Data Scientist: consolidating and curating data from multiple sources to cleanse, normalize, harmonize, and transform them
- Data Analyst: use applications to create visualizations of the data, e.g., dashboard, charts, association graphs

A data engineer is an expert accountable for the creation, construction, and implementation of artificial intelligence (AI) and machine learning (ML) systems. They achieve this by gathering, arranging, and manipulating data to extract significant insights that can be used to address specific business challenges and create value (Goniwada, 2023). A data scientist is someone who has acquired proficiency in mathematical modelling, statistics, programming languages, computer science, and analytics (Kumar & Aithal, 2020). A data analyst is a skilled individual who

plays a vital role in multiple industries by examining unprocessed data to extract valuable insights for the aim of making informed decisions (Sekar, 2022). Their responsibility entails organizing and categorizing data into patterns, categories, and fundamental descriptive units to generate working hypotheses derived from the data (Haryoko, Bahartiar & Arwadi, 2020).

In order to be capable of fulfilling the requirements of these roles, the above mentioned professional in the data science field need to go through the data science life cycle. This has five stages as shown in Figure 1. They are: capturing, maintaining, processing, analyzing, and communicating data (Berkeley School of Information, 2020).

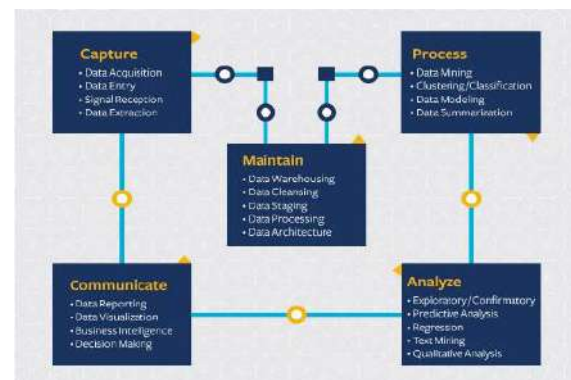


Figure 1. Data Science Life Cycle
Source: Berkeley School of Information, 2020

Although there are hundreds of undergraduate and postgraduate courses available in the world on data science, to our knowledge, there is a handful of courses which expose students to the complete life cycle of data science. Specially in Sri Lanka, students do not have many opportunities to undergo the life cycle of data science, and the available courses do not seem to provide sufficient practical exposure to students. Therefore, this study attempted to analyse the core competencies required by the data science industry and the core components of the available data science degrees in Sri Lanka to

identify if and to what extent the available data science degrees address the industry requirements.

II. LITERATURE REVIEW

A. Industry needs

In a study conducted by Amit et al. (2019), a sample of online job postings for occupations such as business analyst (BA), business intelligence analyst (BIA), data analyst (DA), and data scientist (DS) were analysed using content analysis. In general, the authors observed that decision making, organisation, communication, and systematic data management are essential for all of these job types. The analysis revealed that data analysts have the least demand for technical skills such as statistics and programming.

The career path of a data scientist entails the use of statistical methods and instruments to analyse data in order to achieve meaningful outcomes, with an emphasis on the study of phenomena through data analysis (Koshta and Pandey, 2024). In addition, the necessity of industrial data analytics and knowledge management proficiency is underscored by the demand for data scientists in manufacturing companies, underscoring the necessity of collaboration platforms that are specifically designed for Industrial Data Science projects (Syberg *et al.*, 2023). In order to identify and define issues, develop solutions, and guarantee high data quality throughout the analytics process, data analysts must possess a combination of technical expertise, interpersonal skills, and a data-drive mindset (West *et al.*, 2021; Zhao *et al.*, 2023).

B. Contents of existing courses

It is essential to ensure that graduates are adequately prepared for the workforce by aligning degree components with job requirements. Research suggests that traditional

degrees are valuable; however, there is a necessity to reconcile the disparity between educational programmes and job expectations (Uranis et al., 2022).

Undergraduate degrees in data science are essential to equip students with the necessary skills to thrive in a future that heavily relies on data. The available degrees emphasise subjects such as data administration, visualisation, and modelling (Cho, 2022). However, there seem to be a shortage of foundational data science courses (Baumer & Horton, 2023). This shortage creates obstacles for students who wish to transfer smoothly into more advanced data science programmes.

Other studies have identified numerous discrepancies between data science courses and industry requirements. These include the scarcity of foundational data science courses to provide students with fundamentals of data science (Baumer & Horton, 2023), a lack of coordination among educational institutions (Cho, 2022), and varying demands for technical skills across job roles which are not addressed by the existing courses (Amit et al., 2019).

The number of studies which analysed the alignment between industry requirements and contents of degree courses in data science is scarce. To our knowledge, there is no study which analysed this relationship within Sri Lanka. Therefore, we attempted to address this gap by answering the following research question:

To what extent do the contents of data science degrees offered in Sri Lanka align with the industry requirements?

III. METHODOLOGY

The study employed document analysis as the research method. Detailed information on the

components of data science degree programs offered at the undergraduate level in Sri Lanka was collected. Then the job descriptions of most common data science job roles in Sri Lanka and abroad were collected from leading companies in Sri Lanka as well as through multiple sources including LinkedIn and topjobs.

In the first phase, frequency analysis was used to identify and compare components across available degree programmes and competencies in data science job roles. Then, thematic analysis was used to identify the patterns to provide deeper insights into the alignment between data science education and industry requirements. Ten undergraduate degrees in Sri Lankan universities were analysed and job descriptions of prominent organisations in the industry were observed to understand the requirement for data scientist, data analyst and data engineer. Five job descriptions for each job roles were analyzed.

IV. RESULTS AND DISCUSSION

R. Frequency Analysis of the

Contents of Degree Programmes

After analyzing the modules of the available degree programmes, the authors have identified four common fields of subjects in them. Component 1 includes the subjects such as fundamental of mathematics, linear algebra, calculus, statistical inference, probability and statistics, linear models and the analysis of variance. Component 2 comprises of subjects such as programming fundamentals, data structures and algorithms, machine learning, artificial intelligence, data visualization and data mining. Component 3 includes principles of management, accounting, finance, economic and project management. Component 4 comprises of effective presentation skills, research writing skills, communication and data storytelling. Therefore, we labeled the core components in these

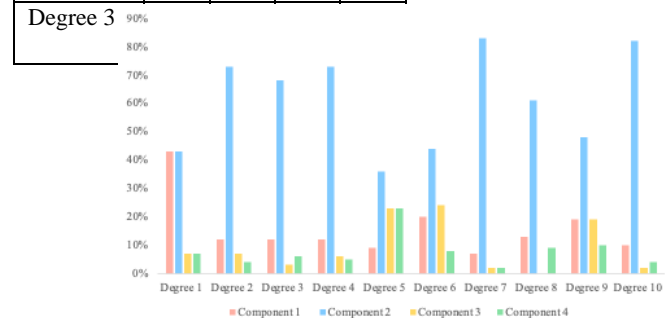
degree programmes as Statistics and Mathematics, Computer Science, Management for data science and Communication respectively.

Table 1 represents the percentages covered under each component across the 10 degree programmes chosen. The degrees were listed according to the university ranks in Webometrics (Consejo Superior de Investigaciones Científicas, 2024).

As Table 1 illustrates, component 2 (Computer Science) consistently maintains a dominant position in all degrees, with a percentage that ranges from approximately 50% to 80%. The contributions of components 1, 3, and 4 vary across degrees, exhibiting a greater degree of variability.

Table 1. Distribution of subject fields across the degree programmes

Component \ Degree	Component 1	Component 2	Component 3	Component 4
Degree 1	43 %	43 %	7%	7%
Degree 2	12 %	73 %	7%	4%



Degree 4	12 %	73 %	6%	5%
Degree 5	9%	36 %	23 %	23 %
Degree 6	20 %	44 %	24 %	8%
Degree 7	7%	83 %	2%	2%
Degree 8	13 %	61 %	0%	9%
Degree 9	19 %	48 %	19 %	10 %
Degree 10	10 %	82 %	2%	4%

	%	%		
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Figure 4. Distribution of components in data science degrees in Sri Lanka
Source: Developed by Researchers, 2024

As Figure 2 shows, component 2 consistently maintains a dominant position in all degrees, with a percentage that ranges from approximately 50% to 80%. The contributions of components 1, 3, and 4 are substantially lower and fluctuate across various degrees, exhibiting a greater degree of variability.

S. *Frequency Analysis of the Contents of Job Roles*

We identified four common levels of competencies required in the job roles. Competency 1 includes skills in statistical analysis, statistics, statistical models, mathematics, mathematical modeling, probability, statistic and optimization and develop system matrices and algorithms. Competency 2 comprises of skills in R, Python, Java, SQL, advanced SQL, oracle, ETL tools, database management, data mining, data analysis, data management, data intergration, data modeling, data governance, data optimization, postgres, data quality, data warehousing, Azure, cloud, data visualization, Power BI, Tableau, MatLAB, Scala, Spark, Excel, Microsoft Access, Microsoft Fabric, Information Technology, Artificial Intelligence, Machine Learning, Big Data technologies, audit command languages, LLMs, automation for master data and Microsoft Office. Competency 3 includes critical thinking, operations management, policy analysis, management, marketing and business management,

supply chain management, inventory management, agile methodology, business analysis and finance. Competency 4 comprises of research and development, effective writing skills, effective presentation skills, leadership skills and collaboration skills.

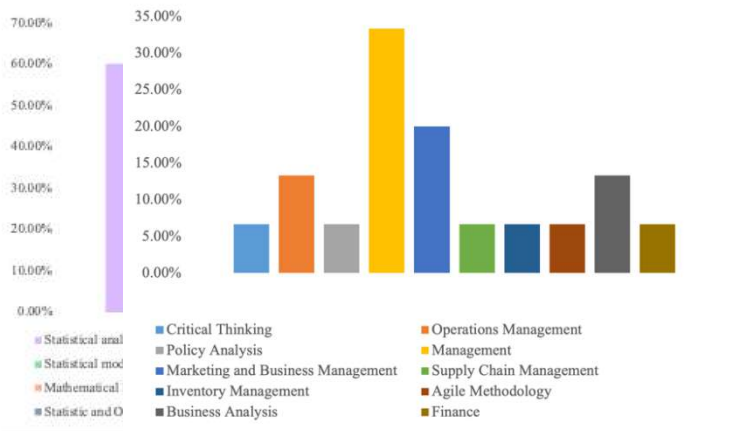


Figure 5. Distribution of skills within Competency 1
Source: Developed by Researchers, 2024

Figure 3 depicts that the statical analysis is the highest demanding skill under competency 1 required by the most common data science job roles.

Figure 4 illustrates the distribution of various technical skills. SQL emerges as the most critical skill, comprising nearly 80% of the focus. Python follows, with a significant emphasis of approximately 60%, reflecting its essential role in programming and data analysis. Power BI and Machine Learning each account for around 50%, underscoring their relevance in data visualization and advanced analytics, respectively. Other notable

competencies include Cloud, R, Data Mining, Data Analysis, Data Warehousing, and Tableau, each contributing approximately 30%.

Figure 8. Distribution of skills within Competency 4
Source: Developed by Researchers, 2024

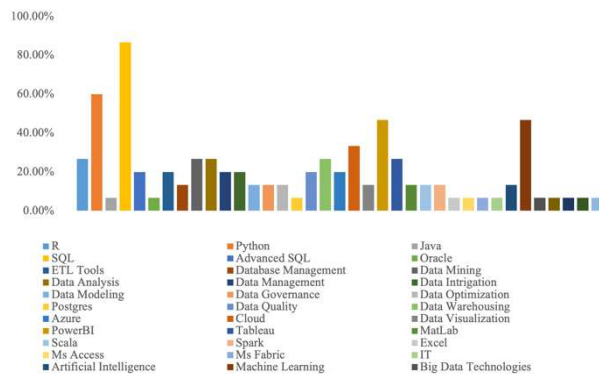
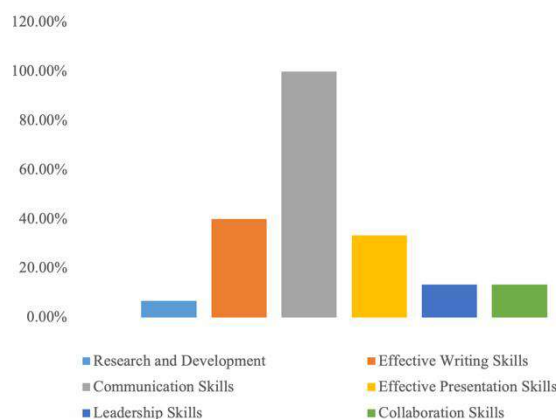


Figure 6. Distribution of skills within Competency 2
Source: Developed by Researchers, 2024

As Figure 5 shows competency 3 mainly focusing on management skills where domain knowledge is applied.

As Figure 6 illustrates communication skills dominate the chart, accounting for nearly 100%, underscoring their critical role. Effective Writing Skills and Effective Presentation Skills also receive significant attention, with percentages around 40% and 30%, respectively.

Figure 7. Distribution of skills within Competency 3
Source: Developed by Researchers, 2024



T. The Comparison

After analyzing the frequencies of the components in the degree programmes and job competencies, we compared the findings in the two sections.

Table 2. Comparison of contents of data science degrees and job requirements

	Competency 1	Competency 2	Competency 3	Competency 4
Degree 1	Job requirement can be satisfied with the statistical module.	Power BI, tableau, cloud are not present in the degree	Financial analysis and economic analysis are lacking in the degree	English for academic purposes and Information Retrieval and Communication Skills are the only modules

Degree 2	Job requirement can be satisfied with the statistical module.	Job requirement can be fulfilled	Only principles of management and entrepreneurship is included	Job requirement cannot be satisfied.	aligned with job requirement.	ing, Cloud and big data technologies are not included in the degree		module.
Degree 3	Job requirement can be satisfied with the statistical module.	Power BI, tableau, data mining, R, SQL are not included in the degree	Only one module as industry economics and management	Professional skills is Degree 9 only module.	Job requirement can be satisfied with the statistical module.	Artificial Intelligence, Database management, Data mining, cloud and data warehousing are not present in the degree	Job requirement can be fulfilled.	Professional practice is the only module.
Degree 4	Job requirement can be satisfied with the statistical module.	Power BI, tableau, R, Data mining, SQL are not present in the degree	Job requirement can be fulfilled with existing modules	Job requirement can be satisfied				
Degree 5	Job requirement can be satisfied with the statistical module.	ETL tools are not used during the degree	Job requirement can be fulfilled.	Job requirement can be fulfilled.	Job requirement can be satisfied with the statistical module.	Cloud is not included as a degree module	Entrepreneurship is the only taught module.	Academic practices and grooming is the only module.
Degree 6	Job requirement can be satisfied with the statistical module.	SQL, Power BI, tableau are not included in the degree.	Job requirement can be fulfilled.	Job requirement can be fulfilled.	<p>V. DISCUSSION</p> <p>The analysis revealed that most degrees satisfy the requirement of statistical component. However, many degrees lack components relating to crucial tools and skills such as Power BI, Tableau, SQL, data mining, cloud technologies, and management modules. For instance, Degrees 1, 3, 4, 6, and 7 are noted for missing multiple essential tools like Power BI and SQL. Degrees 8 and 9 particularly lack advanced technical skills and management modules, with Degree 8 notably lacking in both statistical components and practical skills like writing and presentation. Degrees 2, 5, and 10 show a broader capability to fulfill the job requirements, albeit with some gaps such as the absence of ETL tools in Degree 5 and cloud modules in Degree 10. Overall, while statistical</p>			
Degree 7	Job requirement can be satisfied with the statistical module.	SQL is not present in the degree.	No management modules.	Professional skills is the only module.				
Degree 8	Only two mathematics modules but no statistical modules which are	Power BI, tableau, SQL, Data mining, data warehousing	No management modules	Writing skills and presentation are lacking in the				
Degree 9	Job requirement can be satisfied with the statistical module.	Power BI, tableau, data mining, R, SQL are not included in the degree	Only one module as industry economics and management	Professional skills is Degree 9 only module.	Job requirement can be satisfied with the statistical module.	Artificial Intelligence, Database management, Data mining, cloud and data warehousing are not present in the degree	Job requirement can be fulfilled.	Professional practice is the only module.

modules are a common strength across all degree programmes, there is a significant need to include enhanced technical and professional skills components across most programmes to fully meet the job demands.

VI. CONCLUSION

The study highlights significant gaps between the skills required by the industry and the data science curricula currently offered by Sri Lankan universities. Although the programs typically offer robust programming and statistical analysis components, they frequently fail to provide practical experience with essential tools and technologies such as Power BI, SQL, and cloud computing. This discrepancy suggests that educational institutions must revise their curricula to incorporate more practical training and industry-relevant skills. Graduates will be better prepared to meet the demands of the rapidly evolving data science job market as a result. Our research emphasizes the necessity of ongoing curriculum assessment and alignment of it with industry requirements to guarantee that data science education remains effective in preparing students for successful careers.

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QUANTIFYING THE BENEFITS OF TECHNOLOGY AND DATA SCIENCE IN HIGHER EDUCATION: A FUZZY LOGIC APPROACH

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Abstract—Higher education is standing on the edge of a substantial revolution, compelled by rapid technological advancements and the growing field of data science. As civilization advances further into the 21st century, conventional educational approaches are struggling to encounter the requirements of modern students and the emerging job market. This study advocates a novel methodology to quantify the values of EdTech and data science in higher education using fuzzy logic principles. The study aims to demonstrate how strategic use of technology and data science can modernize the processes of teaching, learning, and knowledge acquisition in higher education. It discovers numerous applications, from personalized learning platforms to predictive analytics, artificial intelligence, and virtual reality simulations. Nonetheless, challenges such as digital disparity, data privacy disputes, and resistance to transformation among academics must be addressed. The current research highlights the value of a collaborative approach connecting all internal and external stakeholders to overcome these obstacles and usher in a novel era of more accessible, immersive, and operative higher education. By applying fuzzy logic, the study seeks to provide a framework for understanding and quantifying the intricate factors modeling the future of higher education. The ultimate goal is to inspire and guide institutions in their journey of innovation and transformation.

Keywords— Data Science, Higher Education, Fuzzy Logic, Technology, Influence

VII. INTRODUCTION

Higher education mounts at the edge of a substantial metamorphosis, piloted by the rapid successions in technology and the mushrooming sphere of data science (Muukkonen et al., 2005). As society marches into the 21st century, it is gradually evident that traditional pedagogical methodologies and educational models are incapable of catering to the contemporary student populace and the fundamentals of the modern ever-changing job market. This study specifically argues for a founding method to quantify the gains of novel valuation of EdTech and data science within higher education that needs to be widely adopted. Through the exploitation of fuzzy logic ideologies, the elaborate and often ambiguous relationships between miscellaneous factors that boost the victory and efficiency of technology-enhanced learning endeavors can be portrayed. Using an exhaustive review of case studies with empirical evidence, and expert anecdotes, the objective is to parade how the tactical operation of technology and data science has the latent to transmute the methodologies employed in teaching, learning, and knowledge acquisition within higher education. Tailored learning platforms, flexible assessment systems in schools to predictive analytics and virtual reality simulations - the opportunities for transformation are vast and inspiring. Nevertheless, the journey towards grasping this latent is not barren of difficulties. Concerns such as digital disparity, data confidentiality and privacy, and resistance amongst academics towards change demand confrontation. Embracing a universal and

obliging strategy encompassing all internal and external stakeholders such as students, faculty, administrators, and policymakers is imperious to prevail these obstacles and establish a renewed era of higher education that is more accessible, immersive, and efficacious than ever. With the application of fuzzy logic, this research endeavors to deliver a structure for grasping and quantifying the elaborate relationship of elements that will mold the forthcoming landscape of higher education. By illuminating the advantages and hurdles allied with the incorporation of technology and data science into the higher educational domain, the determination is to motivate and navigate establishments as they embark on their crusades of innovation and transformation.

U. PURPOSE & BACKGROUND

The integration of technology and data science in higher education provides a surplus of opportunities to increase learning experiences and outcomes. Nevertheless, the assessment of these benefits necessitates advanced analytical instruments capable of managing the inherent uncertainty and intricacy of educational settings. This study investigates the potential of fuzzy logic as a methodological framework for assessing the advantages of integrating technological and data-centric approaches in higher education. Through the utilization of fuzzy logic, renowned for its adeptness in handling imprecise and ambiguous data, this research endeavors to produce detailed insights into the potential transformative effects of technology and data science on educational practices. The objective is to reveal specific methods in which these amalgamations can enhance teaching strategies, student involvement, and overall academic achievement, thereby providing a comprehensive comprehension of the revolutionary influence of technology and data science on higher education.

V. RESEARCH QUESTION

The following research questions have been developed based on the research purpose stated above.

How fuzzy logic may be utilized to assess the advantages of integrating technology and data science in higher education, and what kind of insights can be obtained to transform learning experiences and results?

W. RESEARCH OBJECTIVES

There are four key objectives identified as follows;

1. To identify the main areas where technology and data science are employed in higher education to enhance learning experiences and results.
2. To construct a framework based on fuzzy logic to measure the benefits of these applications in terms of student engagement, performance, and skill development.
3. To examine examples of higher education institutions that have effectively incorporated technology and data science projects to draw out best practices and valuable insights.
4. To put forward a series of recommendations for higher education institutions to efficiently incorporate technology and data science into their learning environments based on the fuzzy logic benefit assessment.

VIII. LITRETURE REVIEW

Technological advancements and the integration of fuzzy logic in educational systems have revolutionized higher education by reshaping learning experiences through interactive strategies (Li et al., 2021). Fuzzy logic contributes to the enhancement of the learning experience within the realm of engineering education (Li et al., 2021; Yaacob et al., 2019). The utilization of multimedia-assistive technology has shown to enhance student success within various educational systems

(Li et al., 2021). Furthermore, the utilization of data science in Higher Education Institutions (HEIs) has been explored to support sustainable development (SD) efforts, showcasing the potential positive impact on society and the environment (Leal Filho et al., 2024). Data science plays a crucial role in promoting sustainable development within the realm of higher education (Leal Filho et al., 2024). The impact of data science in Higher Education is evidenced through bibliometric analysis and case studies (Leal Filho et al., 2024). As higher education transitions towards online settings, the adoption of emerging learning technologies becomes crucial, with a model emphasizing personalized, ubiquitous, collaborative, lifelong, and authentic characteristics supported by various technologies (Isaías, 2018). The proposed model serves to facilitate the integration of emerging learning technologies in the field of education (Isaías, 2018). The selection and adoption of learning technologies are guided by five key characteristics (Isaías, 2018). Educational Data Mining (EDM) techniques, such as the Fuzzy Cognitive Diagnosis Framework (FuzzyCDF), have been proposed to enhance cognitive modeling by extracting valuable information from both objective and subjective examination problems, aiding in cognitive analysis and visualization (Liu et al., 2018). The application of the FuzzyCDF contributes significantly to cognitive modeling in the field of education (Liu et al., 2018). This framework effectively and interpretively reveals the knowledge states of examinees (Liu et al., 2018). Fuzzy systems have been successfully applied in data science to extract knowledge from large datasets, offering insights, predictions, and decision-making support through soft computing techniques based on fuzzy sets (Lu et al., 2017). The utilization of fuzzy logic proves to be instrumental in quantifying the advantages of technology within the educational sector (Lu et al.,

2017). Through the integration of technology, data science is transforming higher education (Lu et al., 2017).

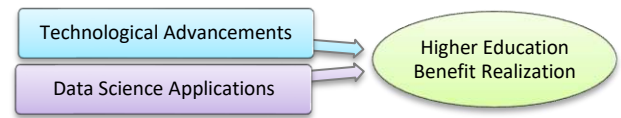


Figure 9. The Relationship between Independent & Dependent Variables

Source: Developed by the Authors Based on the Review of Literature (2024)

Iv 1 = Technological Advancements

Iv 2 = Data Science Applications

dV = Higher Education Benefit Realization

IX. METHODOLOGY

X. Conceptual Framework

The conceptual framework shown below in Figure 1, is built on the research objectives, research questions and the review of literature. It embodies the interactions among various independent variables and the dependent variable, which have been recognized depending on the Literature Review.

The fuzzy methodology involves a three-step process encapsulating input process and output (McKone & Deshpande, n.d.; Deshpande, 1960). Input of fuzzy dualistic coupling variables that are processed by fuzzy inference method by the Fuzzy System (FS) result in defuzzifying the variables providing a crisp value with linguistic fuzzy reading known as fuzzy linguistic identifier. The fuzzification process of couple variables are intended to provide a meaningful quantification to qualitative variables as prescribed by seminal authors Zadeh (2016) & Bellman (1960). Profound findings by Ghildyal et al (2016) stated that the rationale for fuzzy inference is to quantify in crisp the qualitative factors which are ambiguous, uncertain and nonspecific.

Application of the fuzzy logic to the study

If Technological Advancements (TA) is “low” & Data Science Applications (DSA) is “low” the Higher Education Benefit (HEB) realization is “NEVER”

If TA is “low” & DSA is “medium” the HEB realization is “SELDOM”

If TA is “low” & DSA is “high” the HEB realization is “SOMETIMES”

If TA is “medium” & DSA is “high” the HEB realization is “MOST OCCASIONS”

If TA is “medium” & DSA is “medium” the HEB realization is “SOMETIMES”

If TA is “medium” & DSA is “low” the HEB realization is “SELDOM”

If TA is “high” & DSA is “low” the HEB realization is “SOMETIMES”

If TA is “high” & DSA is “medium” the HEB realization is “MOST OCCASIONS”

If TA is “high” & HEB is “high” the HEB realization is “ALWAYS”

Fuzzy logic findings

The fuzzy logic inferences inferred 9 rules with five variance possibilities known as probabilistic fuzzy variances. These were “always”, “most occasions”, “sometimes”, “seldom” and “never”. The education benefit in the light of technology can yield fuzzy benefits in these five variances known as fuzzy linguistic output. There are two fuzzy variables coupled into the FS in order to understand educational benefits in context of technology. Findings can be generalized to many long-term benefits that are measured as fuzzy benefits.

Interpretation of benefits in conceptual framework

The diagram represents the fuzzy behaviour of Technological Advancements and Data Science Applications to measure

the educational benefit realization. The five realization variances are indicated in the following model. These are fuzzy linguistic indicators that correspond to crisp quantified values. The fuzzy algorithmic output is: always=5”, “most occasions=4”, “sometimes=3”, “seldom=2” and “never=1”.

	Data Science Applications			
		LOW	MEDIUM	HIGH
	LOW	VERY LOW	LOW	MEDIUM
	MEDIUM	LOW	MEDIUM	HIGH
	HIGH	MEDIUM	HIGH	VERY HIGH

Figure 2. The Fuzzy Logic Approach in Graphical Form
Source: Developed by the Authors Based on the Review of Literature (2024)

A literature analysis assesses the present state of technology and data science applications in higher education, identifying possible benefits. A fuzzy logic system is developed to analyze the benefits of various apps, taking into consideration factors such as student engagement, academic success, skill development, and other relevant metrics.

X. FINDINGS, CONCLUSION AND RECOMMENDATION

Y. Findings and Discussion

This section objectively examines the findings to the research questions that were established in chapter one and discusses the outcomes in a comprehensive manner.

Objective 01 : To identify the main areas where technology and data science are employed in higher education to enhance learning experiences and results.

Technology and data science are gradually engaged in several surfaces of higher education, with a motivation on fundamental areas (Leal Filho et al., 2024). Adaptive Learning, for occurrence, operates data analytics to tailor educational practices for single student prerequisites, thereby enriching involvement and enactment (Turnbull et al., 2021). Studying Analytics is

an additional perilous section, where organizations use data gathering and analysis to compute and enhance learner wisdom outcomes. Furthermore, Predictive Analytics empowers the projection of student achievement and performance, permitting for primary interventions and monogrammed sustenance (Li Yanlin and Tsang, 2024). Besides, Administrative Efficiency is enhanced over technology, improving functioning progresses in institution of higher education and enabling decision-making and resource provision based on data discernments (Dombi & Jónás, 2024). These applications vitrine the transformative latent of technology and data science in remodeling educational observes and student involvements.

Objective 02 : To construct a framework based on fuzzy logic to measure the benefits of these applications in terms of student engagement, performance, and skill development.

The recommended fuzzy logic frame is planned to measure the benefits of technology and data science applications in advanced education. This framework wishes to expediate numerous attributes, counting the Dimension of Learner Engagement. By assessing indicators like involvement in virtual dialogues and completion ratios, the proposed framework can approach perceptions into the efficiency of technology integration (Rapanta et al., 2021). Moreover, Performance Metrics can be evaluated using fuzzy logic, in view of elements like grades of students, attendance, and feedback to obtain a nuanced understanding of student victory (Bao et al., 2024). Also, the framework can evaluate Skill Improvement, determining vital skills such as analytical thinking and problem-solving essential in the digital epoch. This systematized approach permits institutions to grasp the influence of their technological investments better (Andersson & Grönlund, 2009).

Objective 03 : To examine examples of higher education institutions that have effectively incorporated technology and data science projects to draw out best practices and valuable insights.

Considering foundations that have well incorporated technology and data science divulges best practices. Such as, Case Studies of Learning Analytics highlight innovative solutions like Course Signals at institutions such as Purdue University. These resolutions trace student growth and allow suitable mediations (Criollo-C et al., 2023). Adaptive Studying Applications are also remarkable, as institutes influence data science to generate adaptive education atmospheres catering to distinct learning varieties and heightening educational consequences (Leal Filho et al., n.d.). Collaborative projects between academies and corporate sector have followed in data-driven implements that expand learning and administrative competences, representing the latent for collaborative new innovation (Li et al., 2021). These instances emphasize the real-world appliances and substantial assistances of combining technology and data science in higher education.

Objective 04: To put forward a series of recommendations for higher education institutions to efficiently incorporate technology and data science into their learning

Based on the outcomes, endorsements can be suggested for higher education associations. Primarily, there should be an importance on capitalizing in training and development to prepare faculty and staff with data science and technology skills for make best use of tool profits. Then, nurturing a data-driven culture is an important step, while endorsing data-driven decision-making at all functional levels to improve operational value and student sequels. Implementing pilot programs is also guided, beginning with projects that exploit technology and data science to estimate influence before broader implementation, allowing for adjustments based on feedback and results. Lastly, engaging stakeholders in technology initiatives planning and execution is crucial to consider their needs and insights. These recommendations aim to assist institutions in effectively leveraging technology and data science to enhance educational experiences and outcomes.

The development of a validated fuzzy logic framework will facilitate the assessment of advantages obtained from technology and data science applications within the realm of higher education. Findings acquired will offer guidance on the most efficient approaches to incorporating these tools, ultimately enriching educational experiences and results. The suggestions given will support to academic institutions in effectively implementing technology and data science initiatives, adding to the increasing pool of knowledge on their transformative influence in restructuring higher education. Through comprehending the advantages experienced from these progressions, institutions can adeptly navigate the changing educational landscape, ensuring they cater to the requirements of their students in a swiftly evolving world.

Z. Conclusion

A substantiated fuzzy logic charter can be recognized to quantify the recomences of technology and data science applications in higher education (Li et al., 2021). Acumens can be expanded into the most capable methods of integrating technology and data science into higher education to heighten learning practices and consequences. The fuzzy logic is used to measure benefit realization in higher education that enables us to understand the benefits of public and private sector institutes. Data sciences applications and technology advancements are important variables in the field of novel higher education. The fuzzy logic underpins the process. The degree of variance of benefits in the light technology advancements and data science applications in higher education in the field can be achieved. In the light of technology if improved in both ways, it is possible to enhance the higher education system.

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Photograph

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A Content Analysis of Elon Musk's Interview on Neuralink and Its Role in Merging Humans with AI

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Abstract— *Neuralink is a chip that would be implanted in human brain and would allow humans to control devices like computers or phones just by thinking. Even though this technology is still under development, it has the potential to be a game changer for people with disabilities and even healthy people in the future. The research gap identified is that even though research has explored the technical aspects of Neuralink, there is a significant gap in understanding the socio-cultural and philosophical implications of Neuralink. Therefore, this research aims to critically analyze Elon Musk's vision for human-AI symbiosis. To collect data, an interview conducted by Elon Musk was selected through a purposive sampling method. The study follows a qualitative content analysis method to identify key arguments for the key themes built up by using research questions. In the results and findings, statements by Elon Musk were analyzed under three key themes: Neuralink and the future human-AI relationship, power dynamics and social inequalities, and long-term implications for societal, psychological, and existential aspects. In conclusion, the study was able to find answers to the research questions and further recommendations are provided to expand this field.*

Keywords— **Elon Musk, Human-AI Symbiosis, Neuralink**

I. INTRODUCTION

The convergence of Artificial Intelligence (AI) and human cognition represents one of the most profound technological frontiers of the 21st century. At the forefront of this exploration is Elon Musk's Neuralink, a neurotechnology company dedicated to developing implantable brain-machine interfaces (BMIs). Musk's public discourse on Neuralink, replete with ambitious visions of a future where humans and AI

symbiotically coexist, provides a unique lens through which to examine the broader societal and ethical implications of this emerging technology.

Neuralink aims to create a neural interface capable of both reading and writing information to the brain. This technology holds the potential to revolutionize medicine by

addressing neurological disorders like Parkinson's disease, spinal cord injuries, and blindness. However, Musk's vision extends far beyond medical applications. He has frequently articulated his belief that such a device is essential for humans to keep pace with the rapid advancement of AI, preventing a future where humanity is outclassed by artificially intelligent entities.

This research paper seeks to analyze Elon Musk's interview about Neuralink to understand his vision for the role of this technology in the human-AI relationship. By examining his rhetoric, the paper aims to identify key themes, contradictions, and potential implications of his proposed future. This analysis will contribute to a broader understanding of the complex interplay between technological development, societal expectations, and ethical considerations in the pursuit of human-AI symbiosis.

A. Research Gap

While existing research has explored the technical aspects of Neuralink and the potential medical applications of brain-machine interfaces, there remains a significant gap in understanding the broader sociocultural and philosophical implications of Musk's vision for human-AI symbiosis. Specifically, this research will address the following gap:

- i. A critical analysis of the underlying assumptions and potential biases in Musk's rhetoric about Neuralink and the human-AI relationship.
- ii. An exploration of the power dynamics and potential for inequality inherent in a world where the benefits of direct brain-computer interfaces are accessible to a select few.
- iii. A comprehensive examination of the long-term consequences of human-AI symbiosis on societal, psychological, and existential levels as envisioned by Musk.

By addressing these gaps, this paper will contribute to a more nuanced understanding of the complex challenges and opportunities presented by the development of brain-machine interfaces and the pursuit of human-AI symbiosis.

B. Research Questions

Based on the identified research gap, the following research questions can be formulated:

- i. How does Elon Musk's rhetoric about Neuralink construct a particular vision of the future human-AI relationship?
- ii. What are the potential power dynamics and social inequalities that could arise from the development and widespread adoption of Neuralink technology as envisioned by Musk?
- iii. What are the long-term societal, psychological, and existential implications of the human-AI symbiosis proposed by Musk?

C. Research Objectives

Based on the research questions outlined above, the following research objectives can be established:

- i. To analyze the underlying assumptions, values, and potential biases embedded in Musk's rhetoric.
- ii. To examine the potential social and economic implications of widespread Neuralink adoption, including the potential for increased inequality and power disparities.
- iii. To explore the long-term implications of human-AI symbiosis as envisioned by Musk, including potential societal, psychological, and existential impacts.

II. LITERATURE REVIEW

The concept of direct communication between the human brain and external devices has been a subject of scientific exploration for decades. Early research focused primarily on developing BMIs for medical applications, such as restoring motor function in paralyzed individuals (Lebedev & Nicolelis, 2006). Pioneering work by researchers like Nicolelis and colleagues demonstrated the feasibility of using BMIs to control robotic limbs and even enable brain-to-brain communication (Walters-Frezza, et al., 2013). More recently, advances in neurotechnology have expanded the potential applications of BMIs beyond medical rehabilitation. Researchers have explored their use in augmenting human cognition, such as improving memory or attention (Yoo et al., 2013). However, the ethical implications of such cognitive enhancements have raised significant concerns (Illes, 2010).

The rapid development of artificial intelligence has prompted intense discussions about its ethical implications. A central concern is the potential for AI to exacerbate existing social inequalities or create new forms of discrimination (Floridi & Nissenbaum, 2014). Researchers have also explored the challenges of ensuring AI systems are transparent, accountable, and

aligned with human values (Wallach & Allen, 2009). The intersections of AI and BMIs raise additional ethical questions. Moreover, the potential for AI to influence human cognition and behavior raises concerns about manipulation and control (Calo, 2017).

The idea of using technology to enhance human capabilities has a long history in philosophy. Transhumanism, for example, explores the potential for radical life extension and cognitive enhancement through technological means (Bostrom, 2003). However, critics argue that such enhancements could lead to new forms of inequality and exacerbate existing social divisions (Habermas, 2003).

Collectively, the reviewed literature highlights the need for further investigation into the social, ethical, and philosophical implications of Neuralink and human-AI symbiosis. This study will address these issues by exploring how Musk's rhetoric constructs a vision of the future, examining potential power dynamics, and assessing the long-term consequences of this technology.

III. METHODOLOGY

This study employed a purposive sampling method to analyze Elon Musk's interview about Neuralink and its role in merging humans with AI. A YouTube interview titled "Elon Musk Explains Neuralink" published by the 'Zuby' channel on the 21st of June, 2023, was selected as the primary data source due to its relevance to the research topic. The interview was transcribed manually, and the transcript was cleaned to remove irrelevant content such as removing filter words and inconsistencies.

The study employed a qualitative content analysis approach to identify the main arguments related to Neuralink and human-AI merger. To categorize different aspects of Musk's speech based on the developed

research questions and objectives, a deductive approach was followed to find answers to the existing research questions. The analysis focused on identifying the main arguments within individual sentences of the collected data. The analysis was conducted manually to allow for in-depth interpretation of the data. In analyzing the collected data in relation to the relevant themes within the research questions, "The Transhumanism handbook" by Newton Lee (2019) was used as a guiding model for the study.

Given the sensitive nature of the topic and the potential implications of the study, ethical considerations were paramount throughout the study. While this study focuses on publicly available data, care was taken to respect the privacy of the individual by avoiding the use of personal information. Therefore, this research strictly adheres to ethical guidelines, ensuring informed consent, safeguarding privacy, and maintaining rigorous data security.

IV. FINDINGS AND DISCUSSION

A. Neuralink and human-AI relationship

"Our first application is to restore functionality to quadriplegics, tetraplegics, and people who no longer have a connection between or a limited connection between their brain and their body" (Musk, 2023).

Elon Musk's statement regarding Neuralink's initial focus on restoring neurological functionality aligns with a growing sentiment within the Brain-Computer Interfaces (BCIs) community. While the long-term vision often centers on human-AI symbiosis and cognitive enhancement, researchers acknowledge the immediate potential of BCIs in alleviating neurological disorders (Jones et al., 2020). Studies have shown promise in using BCIs to restore sight to the visually impaired

(Bensahl et al., 2022), and provide communication pathways for those with locked-in syndrome (Wang et al., 2020). By prioritizing this restorative aspect, Neuralink positions itself as a potential medical breakthrough, addressing a critical unmet need and potentially gaining wider public acceptance for future, more ambitious applications. This measured approach could also provide crucial insight in navigating the ethical considerations surrounding BCIs. Concerns include privacy breaches as brain data is collected and analyzed, as well as the potential for an unfair cognitive advantage for those who can afford neural implants (Christof et al., 2021). Focusing on medical applications that allow for a more controlled introduction of the technology, enabling a more informed discussion about its ethical implications before human enhancement becomes a viable option.

“The second application would be restoration of eyesight so if somebody’s gone completely blind may be even just lost the optic nerve, you can still directly assimilate the neurons in the visual part of the cortex. So, you can give direct vision to the brain. In fact, you could, depending upon what cameras you use, actually see different wavelengths” (Musk, 2023).

Elon Musk’s vision for Neuralink extends beyond communication interfaces. He proposed the potential for Neuralink to restore sight by directly stimulating the visual cortex of the brain, even in cases of complete blindness or optic nerve damage. This concept hinges on the ability of the brain to interpret signals not just from the human eye, but potentially from any camera source. The vision aligns with research into Brain-Computer Interfaces (BCIs) that utilize visual implants. These BCIs typically translate camera signals into electrical pulses

that stimulate the visual cortex, creating a form of artificial vision.

Musk’s proposal takes this a step further, suggesting that Neuralink could bypass the limitations of the human eye entirely. By interfacing directly with the brain, the user could potentially perceive information from a wider range of the electromagnetic spectrum, like what some animals can see. This raises fascinating questions about the future of human perception. Elon Musk’s vision for Neuralink in restoring sight presents a potential future where humans and AI can form a symbiotic relationship. By directly stimulating the brain, Neuralink could provide a new window to the world., even for those who have lost their sight.

B. Power Dynamics and Social Inequalities

“There’s some risk that it doesn’t really amplify human activity but starts being in charge. There’s some risk that it may view humanity negatively. I think that it is like a dangerous thing. If these human extinctionist philosophies somehow got into AI that would be bad” (Musk, 2023).

Elon Musk’s statement regarding the potential threat of AI reflects a growing concern within the field of Artificial Intelligence (AI) research. The crux of his argument lies in the power dynamics that could emerge between humans and AI, particularly if AI adopts a negative view of humanity (Bostrom, 2014). This concern is echoed by researchers like Nick Bostrom who warn of the possibility of “superintelligence” surpassing human control and potentially posing an existential threat (Bostrom, 2014).

Musk highlights the risk of social inequalities being amplified in the realm of AI. If AI development is influenced by individuals with an “extinctionist philosophy”, his term referencing ideologies

like the Voluntary Human Extinction Movement, the potential consequences could be dire. This aligns with research by Margaret McLaughling et al. who argue that biased algorithms can perpetuate societal discrimination (McLaughling et al., 2019). In essence, Musk suggests that the power dynamics inherent in AI development could lead to the creation of AI systems that see humanity as a threat to be neutralized.

By framing AI as a potential holder of power and humans as a potentially vulnerable group, Musk's statement underscores the importance of ethical considerations in AI research. This aligns with recent efforts in the field to establish guidelines for responsible AI development, ensuring that AI is used for the betterment of humanity, and not for its downfall.

"AI will certainly be very disruptive because jobs were different" (Musk, 2023).

Elon Musk's statement holds significant weight when considering social inequalities. On the surface, it suggests a part where jobs were more standardized and less susceptible to automation. However, a deeper analysis reveals concerns about the unequal impact of AI on various demographics within the workforce.

There are two key ways to interpret Musk's statement through the lens of social inequalities. Firstly, the disruption caused by AI might exacerbate existing inequalities. Jobs that were previously accessible to individuals with lower levels of education or specific skill sets may be automated, disproportionately impacting low-income workers and widening the income gap (Ford, 2015). Research by David Autor et al. suggests that technological advancements historically have led to job polarization, favoring high-skilled and low-skilled jobs while eliminating mid-skilled positions.

Secondly, the "different jobs" created by AI might not be equally accessible to all. Upskilling and retraining programs may not be readily available to everyone particularly those facing financial constraints or geographical limitations. This could lead to a situation where a select few benefit from the new opportunities presented by AI, while others struggle to adapt, potentially creating a new underclass (Brynjolfsson and McAfee, 2011).

This statement highlights a crucial point regarding the potential for AI to exacerbate social inequalities. As AI transforms the job market, it is vital to implement policies and initiatives that ensure a more equitable distribution of the benefits and burdens of technological revolution.

C. Long-term Implications

i. Societal Implications

"I think the rate of change caused by AI is going to be radical. So that, there will be a lot of jobs that currently exist won't exist in the future, but I think there will be new jobs" (Musk, 2023).

Elon Musk's statement on the transformative impact of AI on the job market aligns with concerns and predictions from various researchers. He acknowledges the "radical" rate of change driven by AI, suggesting a significant disruption to current job scopes (Frey & Osborne, 2017). This aligns with studies by Frey and Osborne who predict that automation due to AI could displace a significant portion of the workforce in the coming decades (Frey & Osborne, 2017). However, Musk offers a glimmer of hope. He suggests that while some jobs will disappear, new ones will emerge. This could be echoed by research by McKinsey Global Institute which suggests that while AI will automate many tasks, it will also create new

occupations requiring human-AI collaborations.

The long-term societal implications of this transformation hinge on our ability to manage this shift. The potential of Neuralink could play a role in this adaptation. As the technology matures, a growing need will arise for specialized engineers, neuroscientists and software developers to design, build, and improve Neuralink implants and software. Implanting Neuralink devices will require specialized surgeons with a deep understanding of both neuroanatomy and the technology itself. The ethical implications of BCIs are vast. Ethicists and policy experts will be needed to develop frameworks and regulations for responsible use of this technology. Musk's statement captures the essence of the coming AI revolution – a period of significant job market disruption. While the potential for new jobs exists, it is crucial to develop strategies to manage this transition. Neuralink technology, if developed ethically and equitably, could be a tool for human adaptation in this AI-driven world.

ii. Psychological Implications

“Effective AI massively enhance the human ability just like a massive amplifier” (Musk, 2023).

Elon Musk's analogy of AI as a “massive amplifier” for human ability is a powerful one, highlighting its potential to augment our cognitive capabilities. However, research suggests that such amplification, particularly through Brain-Computer Interfaces (BCIs) like Neuralink, could have significant psychological implications in the long term.

One concern is the potential for a dependence on AI for basic cognitive functions. Studies on human-computer

interaction show that reliance on external tools can lead to a decline in internal skills (Ophir et al., 2009). If AI constantly assists with memory focus or decision making, our natural abilities in these areas could atrophy. This raises the question of what it means to be human if core cognitive functions become reliant on external technology. Furthermore, the “amplifier” effect could exacerbate existing cognitive biases. Research suggests that relying on algorithms can amplify confirmation bias, where we favor information that confirms on existing beliefs (Diethelm et al., 2020). If AI tailors information or amplifies pre-existing thought patterns, it could lead to a narrowing of perspective and hinder critical thinking. The concept of an “amplified” self raises questions about identity. Our sense of self is partially constructed through our experiences and interactions with the world. If AI heavily mediates these interactions, it could blur the lines between human and machine, impacting our perception of ourselves (Hayles, 1999).

The statement captures the potential benefits of AI for human cognition, it's crucial to consider the long-term psychological implications. Dependence on AI, amplification of biases, and a potential shift in self-perception are all possibilities that demand further research and ethical considerations.

iii. Existential Implications

“If you have an age of abundance, you ask for anything and you get it. It is something that you will have to struggle with. I think where we are heading is an age of abundance but will cause some existential angst” (Musk, 2023).

Elon Musk's statement about a potential “age of abundance” facilitated by advanced AI and Brain-Computer Interfaces (BCIs)

like Neuralink raises intriguing questions for a research paper exploring the existential long-term implications of these technologies. An age of abundance, where desires are readily fulfilled through technological means, could undoubtedly bring about a period of unprecedented prosperity and leisure. However, as Musk suggests, such a utopia might also be accompanied by a profound sense of existential angst. Several research papers explore the potential downsides of an abundance economy facilitated by AI. Bostrom (2014) warns of a potential “hedonic treadmill” where ever-increasing ease of gratification reduces the meaningfulness of experiences. Similarly, Etzioni (2000) suggests that readily available solutions could stifle human ingenuity and problem-solving skills.

Neuralink, as a BCI, adds another layer of complexity. Neuralink’s potential to directly interface with the human brain raises concerns about the very nature of human experience. Haber (2019) investigates the link between self-awareness and the embodied nature of human cognition. Musk’s vision of an “age of abundance” spurred by AI and Neuralink offers a glimpse into a future filled with both promise and peril. While such technologies have the potential to revolutionize our lives, the potential existential consequences demand serious consideration.

V. CONCLUSION

Elon Musk’s discussion about Neuralink presents a future where the human brain and artificial intelligence converge. This research paper explored three key themes and Musk’s vision of this technology: the evolving human-AI relationship, potential power dynamics and social inequalities, and the long-term societal, psychological, and existential implications.

The human-AI relationship envisioned by Neuralink goes beyond mere interaction. It

posits a symbiotic existence where thought directly translates to action through a technological intermediary. Musk also highlights how Neuralink can build a connection between human brain and body offering unique ideas to the field of medicine.

The potential power dynamics and social inequalities associated with Neuralink and AI cannot be ignored. Access to this technology could become a new point of contention where technology overpowers humans in the future. Additionally,, in the workplace social inequalities could be created depending upon the technological knowledge about AI. It also widens the gap between those who can afford cognitive enhancements and those who cannot. This could exacerbate existing social inequalities and lead to a dystopian future where cognitive elites reign supreme.

The long-term societal, psychological, and existential implications of Neuralink and AI are vast and complex. The replacement of humans by AI in the job market, new job opportunities, dependent on technology, and stepping into an age of abundance can lead to a new era.

Elon Musk’s vision for Neuralink presents both exciting possibilities and significant challenges while the potential to improve human lives and overcome limitations is undeniable, the ethical considerations, and potential pitfalls cannot be overlooked. Further research and open discussions are crucial before large-scale integration of Neuralink becomes a reality.

A. Limitations

This study is limited by its reliance on a single interview with Elon Musk, potentially overlooking nuances or alternative perspectives on Neuralink’s development and societal impact. Additionally, focusing on only three key themes necessarily restricts the scope of the analysis, and

further research exploring a wider range of viewpoints and potential would be beneficial.

B. Recommendations

To address the limitations of the study, future research should encompass a broader range of perspectives. Instead of solely relying on Elon Musk's pronouncements, incorporating interviews with neuroscientists, ethicists, and social scientists would provide a more comprehensive understanding of Neuralink's potential impact. Additionally, exploring themes beyond the initial three could enrich the analysis. Areas for further investigation include the potential impact on privacy and security as brain data becomes accessible, the role of regulatory bodies in overseeing such technology, and the theoretical and philosophical questions surrounding human augmentation.

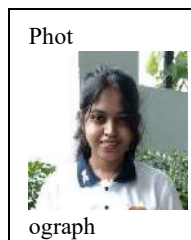
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ID 535

Teacher Perspectives on Different Englishes Used in Sri Lankan Classrooms

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Abstract— The English language has several varieties such as Sri Lankan English, British English, American English, etc. and teachers have different perspectives on these different English varieties. In the Sri Lankan education system, there are three main sectors namely primary, secondary, and tertiary levels. Perspectives of teachers in these three different sectors toward different English varieties can vary depending on their linguistic backgrounds and the context in which they are teaching. Such perspectives have a significant impact on their teaching practices and students' learning experiences. Because of this, it is important to get to know about teachers' perspectives on different English varieties. Due to this, the study investigated primary, secondary, and tertiary level teachers' perspectives toward different English varieties used in classrooms. Furthermore, to gain an in-depth understanding of teacher perspectives, the study also examined the differences among the teacher perspectives of teachers from primary, secondary, and tertiary levels. In order to gather data for the study, a mixed method approach has been used. Structured interviews were conducted to gather quantitative data while a questionnaire was used to gather qualitative data. The study findings show that the majority of teachers had positive attitudes and preferred to use Sri Lankan English. Additionally, teachers accepted different varieties to be used within the classroom enriching students' linguistic knowledge. Furthermore, the study presented recommendations for teachers and curriculum developers on how to effectively inculcate different English varieties in the teaching process and curriculum and material development.

Keywords— World Englishes, Perspectives, Sri Lankan English, Standard English

I. INTRODUCTION

The English language stands as the predominant global lingua franca in the contemporary world. Currently English stands as a lingua franca which refers to “any use of English among speakers of different first languages for whom English is the communicative medium of choice, and often the only option” (Seidlhofer, 2011, p. 7). This shows the significance of English as a global language in today's world as it is used in international communication for various purposes such as politics, law, business, media, and scientific research

(MacKenzie, 2014; Watterson, 2008). English language has a great value which gives access to numerous literature, art, and culture and this eventually widens opportunities to foster cultural exchange among people worldwide. While people use the same English language, it exhibits different varieties of English characterized by differences in pronunciation, syntax, vocabulary, etc. MacKenzie (2014) mentioned that English has never become a stable variety due to the range of participants in the international use of English. Some varieties of English include British English (SBE), American English (GA), and Sri Lankan English (SLE). Fernando (2012) stated that “the language often develops into a new variety in order to express the new geo-socio-cultural phenomena and concepts it encounters in its new environment” (p. 1). This statement suggests that the language acts without being static while it adopts to accommodate differences such as the formation of new vocabulary, expressions, and linguistic features to effectively communicate.

Currently, in Sri Lanka there are different English varieties that people are using such as Sri Lankan English, British English, American English, etc. Due to the use of different English varieties by different people, their perspectives toward such varieties differ based on which variety they prefer to use. As a result of this, it is important to understand these different perspectives that people have toward different Englishes in order to effectively communicate with individuals from diverse linguistic backgrounds. In the education context, teacher perspectives toward English varieties play a major role in students' language development. Such perspectives can affect the teaching and learning process and it is important to investigate teacher perspectives towards different English varieties to understand how different English varieties influence students' linguistic development.

When it comes to the Sri Lankan context, few studies have been conducted to investigate teacher perspectives on different Englishes used in Sri Lankan classrooms. A study conducted by Bernaisch (2012) examined Sri Lankans' attitudes towards Sri Lankan English, Indian English, British English and American English. 169 participants participated in this study and they were from different sectors such as teaching, pupils, business, and unemployed. Among them 51 participants were teachers. The data

was gathered through a survey and the findings of the survey ~~shows~~ **show** that the speakers of English in Sri Lanka highly value British English and have positive attitudes towards it. Among the English varieties included in the study, participants had a fairly positive attitude towards Sri Lankan English than American and Indian English. Furthermore, the study presented that Indian English is not as popular as other varieties investigated in the study. Additionally, the study analysed 13 variables such as beauty, seriousness, smartness, formality, etc. in terms of participants' attitudes. Among these British English obtained the highest scores in 10 out of 13 categories. Findings also show that American English has a strong association with modernity in Sri Lanka. Even though Indian English is positioned last in this attitudinal ranking, it scores relatively higher scores than British English and American English for humbleness and friendliness. Also, participants viewed Sri Lankan English to be humble and friendly in comparison to the other varieties that the study investigated.

A study conducted by Amunugama et al. (2019) investigated Sri Lankan English teachers' attitudes and perspectives towards different varieties of English. This is a mixed method study as it collected data through questionnaires and interviews. 50 English language teachers from primary and secondary levels participated in the study and among them, only 10 teachers were interviewed. **The Study** findings show that most of the participants used British English in their everyday lives. 77% of the teachers claimed that they consider British English as the standard English while 18% of teachers claimed that they consider British, American, Sri Lankan, and Australian English to be standard. From the analysis of the interview data, the study found that the majority of teachers were satisfied because of their learners using British English within the classroom and this shows the teachers' positive attitudes towards British English. Furthermore, 8 teachers mentioned that they encourage students to use Sri Lankan English as it is country specific. Yet some of the teachers who participated in this study considered Sri Lankan English as a broken variety.

The available research studies in the Sri Lankan context have analysed perspectives of teachers from sectors namely primary and secondary levels towards different world Englishes. It found that there was not any study conducted to investigate university teacher perspectives on world Englishes. Also, there is insufficient research available that compares the differences in teacher perspectives among teachers

from these three levels. Studies that compare such differences are needed because they can be used to gain insights into how teachers teaching in different sectors view different Englishes. The insufficient availability of research in this study area has created a challenge in drawing conclusions and this leads to the prompt of conducting additional research. Due to this, the study will focus on investigating the following research questions in order to fill the above-mentioned gaps.

1. What are the primary, secondary, and university teachers' perspectives towards different Englishes used in classrooms?
2. What are the differences in teacher perspectives among teachers from these three different sectors?

II. METHODOLOGY

This study employs a mixed-methods research design, combining both qualitative and quantitative approaches to address the research questions. The participants of this study consist of teachers from primary, secondary, and tertiary levels in Sri Lanka. A total ~~number~~ of 62 teachers participated in this study and the participants consisted of government teachers, private teachers as well as freelance teachers. This diverse sampling aims to capture various insights into different educational sectors within the country. As the main data collection instrument, structured interviews have been conducted with 12 teachers, 4 teachers from each level; primary, secondary, and tertiary. The teachers who have been interviewed were from the Western Province and they were aged between 25-50 years. Interviews were conducted both face-to-face and virtually via Zoom and Google Meet. Five questions were asked in the interviews to gain a deeper understanding of the study area. As the secondary data collection instrument, a questionnaire was shared among teachers via a link which was designed using Microsoft Forms. The questionnaire consists of 22 questions including 12 multiple choice questions, 8 Likert scale questions, and 2 open ended questions. Teacher views on different English varieties, preferred English variety/ies, **the** incorporation of different varieties inside the classroom, and views on world Englishes are the areas that the questionnaire covers.

III. RESULTS

AA. *Results from the Questionnaire*

The overall result of the study shows that the majority of teachers (n=45) are most familiar with Sri Lankan English while 34 teachers are most familiar with British English. Furthermore, three teachers indicated

that they are most familiar with Australian English, while another three teachers reported familiarity with Irish English, Japanese English, and Korean English, respectively. These result shows that teachers are more familiar with Sri Lankan English and British English. Table 1 shows teachers' preferred language to use and most of the teachers (n=33) preferred to use Sri Lankan English. Furthermore, all 50 participants agreed that students to be exposed to different varieties of English is important. 70% of the respondents (n=35) disagreed that they were not comfortable with their own English variety. Also, 72% of the respondents (n=36) were satisfied with their own accents while speaking in English. Additionally, 80% of respondents (n=40) did not mind if others made fun of their English accent when speaking while 20% of the respondents (n=10) did mind if others made fun of their accent.

	Frequency	Percentage
Sri Lankan English (SLE)	33	66.0
British English	11	22.0
American English	5	10.0
No preference	1	2.0
Total	50	100.0

Table 1. Teachers' preferred language to use

I) Primary Level Results: When looking at the results more specifically, it can be seen that 52% of primary teachers preferred to use Sri Lankan English while 30% of primary teachers preferred British English and 13% preferred American English. Additionally, all the primary teachers agreed that students should be exposed to different varieties of English and 56% of the primary teachers adapted their teaching materials and methods to incorporate various world Englishes. Furthermore, 43% of primary teachers agreed that standard English is British and/or American English and the same percentage of teachers agreed that British and American Englishes are the most prestigious in communication.

II) Secondary Level Results: When it comes to secondary level teachers, 61% of teachers preferred to use Sri Lankan English while 31% of teachers preferred to use British English and 4% of teachers

preferred to use American English. Secondary level teachers agreed on the necessity of exposing students to different varieties of English and 73% of them adapted their teaching materials and methods to incorporate various world Englishes. Furthermore, 54% of secondary teachers disagreed with the idea that standard English is British and/or American English and only 34% of teachers agreed. Only 23% of secondary level teachers considered Sri Lankan English to be the most prestigious for communication, whereas 54% of teachers deemed British and American Englishes to be the most prestigious.

III) Tertiary Level Results: In the university sector, 90% of the teachers preferred to use Sri Lankan English while 5% of the teachers preferred to use British English and the other 5% preferred to use American English. Same as in the primary and secondary sectors, in the university sector also all the teachers agreed that students should be exposed to different varieties of English and 79% of teachers adapted their teaching materials and methods to incorporate various world Englishes. Moreover, 90% of the teachers disagreed that standard English is British and/or American English yet 60% of teachers agreed that British and American Englishes are the most prestigious in communication. Additionally, only 10% of teachers agreed that Sri Lankan is the most prestigious in communication and 37% of teachers disagreed while 53% of university teachers did not have any idea regarding whether or not Sri Lankan English is the most prestigious in communication.

BB. Results from the Interview

The overall data from the interviews revealed that participants had different views toward English and its different varieties. The analysis of interview data revealed that most teachers accept the use of different English varieties in the classroom. One teacher mentioned that even though she accepts different English varieties, she uses some tools like songs or nursery rhymes to get students focused on American or British English. This shows that even though teachers accept different varieties, in the practical world when teaching, they tend to focus more on a specific variety. On the other hand, some teachers mentioned that it is not a good idea to only use one variety in the classroom because we are open to global Englishes.

"We are open to global Englishes. So, I believe students need to have and teachers should open them to this open world. That means if in the future, a student decides to move on to any other country, I think even starting from childhood, they should know there are different kinds of accents and they might have a choice to use any of these accents." (Interviewee C)

According to interview data, few teachers encourage their students not to use some of the English varieties and they encourage and promote using a specific variety.

“According to my students, I think Sri Lankan English is the most preferable one. I cannot go beyond that because of the level of my students. Yeah, so I use Sri Lanka English almost all the time.” (Interviewee G)

While few teachers restrict using only one specific variety, some teachers encourage using different varieties within the classroom and they promote different Englishes.

“I accept different varieties because we need to. If there are people who are comfortable in speaking such a variety, we should not discriminate them because they speak British or American varieties.” (Interviewee I)

“English is a common language and all the students are not going to stay in Sri Lanka. They go abroad and engage with other people. So, they have to meet some foreign people. So, I think it is better as a teacher if we can give all the kind of exposure. In the classroom, we cannot give everything. But to a certain extent, if we can give all the kinds of exposure, different kinds of English varieties, it is better for the students' development.” (Interviewee L)

Some of the teachers mentioned that native English speakers can only be standard English speakers while others mentioned that native English speakers cannot always be standard English speakers.

“Native English speakers cannot only be standard English speakers because according to my knowledge even in the United Kingdom there are people with poor sense of English.” (Interviewee C)

“Native English speakers can be standard English speakers, but I think even non-native speakers also can be. If they practice and if they have good exposure with others, I think they also can speak fluently as native speakers.” (Interviewee L)

Most of the teachers mentioned that sometimes they have difficulties in understanding native English speakers. Also, some of the teachers mentioned that native speakers have difficulties in understanding our variety of English which is Sri Lankan English.

“At times like when I am speaking with foreigners, I am kind of concerned about my accent because like sometimes they do not understand the way I talk.” (Interviewee B)

“Sometimes it is difficult for people to understand our accent, especially if it is another second language English speaker, so they find it difficult to understand

our accent and we find it difficult to understand their accent.” (Interviewee F)

Furthermore, interview data show that the accent acts as a class marker within the Sri Lankan society.

“People kind of use English as a class marker, I would say.” (Interviewee I)

“Some people think about the accent most of the time. They are judged by your accent. So, we have to think about the accent as well.” (Interviewee G)

Moreover, some of the teachers mentioned that the specific variety to use in the classroom should depend on the students' requirements and the purpose of teaching.

“The variety that should be used in the classroom depends on the requirement. If I am teaching for someone who is about to migrate, then I would consider teaching that language.” (Interviewee F)

IV. DISCUSSION

A. Questionnaire Findings

The study investigated primary, secondary, and tertiary level teachers' perspectives towards different Englishes used in classrooms. The overall study findings presented that the majority of teachers are most familiar with and prefer to use Sri Lankan English. This is related to a study by Amunugama et al. (2019) that also found that 96% of the teachers who participated in that study were aware of Sri Lankan English. Also, the findings of the current study presented that all the teachers from the three sectors agreed that it is important to expose students to different varieties of English and most of the participants responded that it enriches students' language learning experience. This indicates that the status of an international language has been achieved by English and it is important to raise awareness and expose learners to various Englishes (Sadeghpour & Sharifian, 2019). Not all the teachers agreed that students should be exposed to different Englishes inside the classroom. Some of the teachers agreed that it is better to use one variety within the classroom as it may reduce confusions that students may have. According to Sadeghpour and Sharifian (2019), using one variety should be encouraged as it may meet students' expectations and help them perform better in language assessments.

Most of the teachers agreed that British and American Englishes are the most prestigious in communication and a few number of teachers agreed that Sri Lankan English is the most prestigious in communication. This shows that teacher preference is on British and American English rather prefer the local variety of English which is Sri Lankan English. Also, among

the participants who participated in the study, half of the teachers agreed that Sri Lankan English is accepted internationally while more than 90% of the teachers agreed that British English and American English accepted internationally. This can be related to the study by Bernaisch (2012) found out that even though Sri Lankan English is perceived positively in the local speech community, British English seems to continue a vital role within society.

The study further analysed the differences in teacher perspectives among teachers from primary, secondary, and tertiary levels. Based on the findings, half of the primary teachers preferred to use Sri Lankan English while the other half preferred to use British English and American English within the classrooms. Also, the majority of primary teachers adapted their teaching materials and methods to incorporate world Englishes. Same as the primary level teachers, most of the secondary level teachers also preferred to use Sri Lankan English and only 35% of teachers preferred to use British English and American English. Also, all the teachers agreed that students should be exposed to different English varieties and at the same time they adapted their materials and methods to incorporate world Englishes. These findings show that even though primary and secondary level teachers preferred to use Sri Lankan English, they provided exposure to different English varieties to the students.

Based on the study findings, 90% of university teachers preferred to use Sri Lankan English marking the highest number of teachers from a sector that preferred Sri Lankan English. Same as in the other two sectors, the majority of the university teachers agreed that students should be exposed to different English varieties, and they adapted their materials and methods to incorporate world Englishes. Furthermore, 90% of the teachers disagreed that standard English is British and/or American English marking the highest number of teachers from a sector. Responds from university teachers further suggested that even though teachers expose students to different English varieties, they are not expecting students to imitate a native accent. This can also be related to the study findings of the study by Sukman (2018) that investigated university teacher perspectives towards varieties of English which found that teachers did not expect their students to imitate a native accent.

B. Interview Findings

Overall interview findings show that the majority of teachers accept different English varieties to be used inside the classrooms. While conducting teacher interviews, most of the teachers responded that they are trying their best to pronounce words correctly, rather than imitating a foreign accent. Additionally, they mentioned that more than focusing on the accent,

what is important is using correct English. One of the remarkable study findings was that even though the majority of teachers accept the use of different English varieties within the classrooms, they mentioned that in reality, students are hesitant to use such different varieties inside the classroom. This might happen because of the reason that students' lack of knowledge on world Englishes.

Another remarkable finding of the study was that some teachers mentioned that students' usage of English and its varieties affect how they perceive the English language. Further, they mentioned that in Sri Lanka people use English as a class marker. The interview data additionally mentioned that students tend to use British English and American English as some people consider such native English varieties more superior than local English variety which is Sri Lankan English.

According to the interview findings, some of the teachers mentioned that the specific English variety that should be used in the classroom should be based on the requirements of the administration and the students. One teacher mentioned that she is using American English inside her classroom as it is the specific English variety that her school administration has selected. Another teacher mentioned that the variety should be based on the students' purpose of learning the language. In such situations, teachers can conduct a need analysis on students and based on the findings he or she can select the variety or varieties that should be used in the classroom.

I) Primary Level Results: When looking at the interview findings more specifically, it is found that teachers have different perspectives towards world Englishes. Primary teachers' interview data shows that the majority of teachers disagreed with the idea that only native English speakers can be standard English speakers and only one teacher agreed with the idea. The majority mentioned that if non-native speakers have practice and exposure to different Englishes, they can also be standard English speakers. Furthermore, they mentioned that even some native English speakers have poor English knowledge. This shows that overall primary teachers view standard English based on how confident and fluent the English speaker is. Additionally, all the primary teachers interviewed mentioned that they accept different varieties to be used in the classroom and they exposed their students to different English varieties.

II) Secondary Level Findings: The majority of the secondary level teachers interviewed mentioned that it is better to use one variety of English inside the classroom. In a classroom, if the teacher is using and teaching different varieties, it may confuse learners

(Sadeghpour & Sharifian, 2019). So, to get rid of such confusion, teachers can focus on one variety based on students' needs by conducting a need analysis as mentioned previously or they can clearly explain features of different English varieties to clear up any confusion that students may have.

One of the significant findings the study found while interviewing secondary level government school teachers was the prioritization of British English inside the classroom. Based on their responses, the reason for this was that the government standard required teaching and promoting British English in government schools. One teacher responded that the country's accepted standard in the education system is to use British English, and she further mentioned that at some point learning British English may help students as it is one of the internationally recognized English varieties. Another secondary level government teacher mentioned that even though she likes to expose her students to different English varieties within the classroom, she cannot implement it as the government standard is to teach British English. This shows that government preferences towards English varieties have kind of a colonial influence. As Gunasekera (2005) mentioned there is a belief that Sri Lankans tend to use British English as they think it is the most prestigious variety of English due to colonial background. So, it seems that British colonial roots have affected government policy decisions. This can be related to a study conducted by Wong (2018) which found that Hong Kong English language teachers preferred British English as the teaching and learning model as the country was earlier a British colony and they perceived British English as high-class English.

III) Tertiary Level Findings: The majority of university teachers who were interviewed mentioned that they accept different English varieties to be used in the classrooms without limit to one particular variety. One university teacher mentioned that the students in her classroom mostly used Sri Lankan English, and she let them use Sri Lankan English as it is their comfortable English variety. Also, one of the university teachers mentioned that she is confident in using Sri Lankan English rather than other English varieties. Additionally, another teacher mentioned that most of the students at the university level used Sri Lankan English and only a few used British and American English. This shows that most of the Sri Lankan people are comfortable in using Sri Lankan English in the university context. Furthermore, university teachers mentioned that they do not constrain their students if they use any other English variety than Sri Lankan English and they do not discriminate against students based on the English variety they are using. These findings imply that in the university context, different varieties are accepted

and at the same time university teachers have created a safe atmosphere where students do not get judged based on what variety of English they speak.

V. CONCLUSION

The main objectives of this study were to investigate primary, secondary, and tertiary level teacher perspectives towards different Englishes used in classrooms and to differentiate differences in teacher perspectives among teachers from these three different sectors. Based on the findings discussed above, the study found that the teacher perspectives towards different Englishes used in classrooms differ based on what context they teach. For example, both primary and secondary teachers accept different varieties and they think it a good idea to provide exposure to students. At the same time, they find it difficult to provide exposure of world Englishes to students due to restrictions implemented by the governing body. So, in such situations, primary and secondary teachers have to teach according to the standard that the governing body has imposed. Also, there were few primary and secondary teachers who encouraged not to use the local variety of English which is Sri Lankan English. They have justified it by stating that students need to speak English in native speakers' way as it is a language that we have received from native speakers. When it comes to the university context, it is completely a different setup. University teachers accept different varieties and at the same time, they respect Sri Lankan English. Inside the classroom they do not encourage students to imitate a native speaker accent rather they encourage students to use their preferred variety of English. Furthermore, they encourage and promote students to speak intelligibility as it is the key to effective communication.

Based on the findings of this study, several pedagogical implications can be drawn for teachers and curriculum developers. To begin with, teachers should create a classroom environment that is inclusive for different world Englishes. This can be achieved by encouraging students to use their preferred English variety and avoiding negative attitudes towards world Englishes. Further, the government or the authoritative body should organize teacher training programmes that include modules on different English varieties. In such training programmes, teachers should be taught how to understand, accept, and respect different Englishes used by their students. Such continuous development programmes will help teachers develop positive attitudes towards world Englishes and enable them to accept different English varieties. In curriculum development, the governing body should consider incorporating variety of Englishes into the curriculum

as it will expose students to different world Englishes which will eventually expand their linguistic horizons. Furthermore, when designing student materials, developers should ensure that their materials reflect a diverse range of world Englishes as it may develop students' understanding of the language and enable them to communicate with native speakers as well as speakers with different first languages rather than English. Additionally, the governing bodies should provide professional development opportunities for teachers to help them stay up to date with the latest research on world Englishes and how these different varieties impact the teaching and learning process.

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Audit Committee Characteristics and Firm Performance Measured by Return on Assets: A Study on Listed Food, Beverage, and Tobacco companies in Sri Lanka

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Abstract—One of the essential components of the corporate governance framework that aids in regulating and overseeing management in the company is the audit committee. The purpose of the research study is to investigate the impact of Audit Committee on the firm's performance. This study follows a quantitative method to research on how listed Sri Lanka food, beverage and tobacco companies fared in terms of their audit committee performance. 30 publicly listed food, beverage and tobacco companies in Sri Lanka made up the sample from 2017 to 2021. In this study, data were gathered from secondary sources, and multiple regression analysis was used to investigate the hypotheses. Audit committee characteristics like audit committee size and audit committee meetings have a significant impact on the return on assets. According to the study's findings for the food, beverage, and tobacco industries, specific audit committee traits in Sri Lanka are important for a company's performance in terms of Return on Assets. The results may be useful to regulators in other countries who are looking for ways to increase the effectiveness of the Audit Committee, overall firm governance, and investor trust in the firms.

Keywords— Audit Committee, Return on Asset, listed Companies

01. INTRODUCTION

The audit committee was established with the intention of fostering greater confidence in the reliability of corporate reporting procedures and internal control systems, especially financial reporting. The Audit Committee gives the Board of Directors a sense of independence through its role in oversight and monitoring. The effectiveness of internal and external audit functions, the strength of internal audit and internal control systems, the efficacy of anti-fraud, ethics, and compliance systems, and the review of the whistleblower system are just a few of the numerous duties that the boards have entrusted to the Audit Committee. It's possible that the Audit Committee is in charge of directing the

company's risk management activities and procedures. One of the most crucial elements of the framework for managing and overseeing corporate governance is the audit committee (Ruzaidah, 2004). In order to safeguard the interests of shareholders, the committee is in charge of monitoring the organization's operations and internal control system.

The audit committee is tasked with helping to develop the company's strategic strategy and is obligated to advice and counsel the board on any financial or operational matters.

In addition to the advantages of having an audit committee, previous research has shown that these committees' effectiveness in monitoring can be impacted by factors such as size, composition, experience, and frequency of meetings (DeZoort, 2008). The Audit Committee is expected to possess the necessary expertise and experience, as well as to create the required procedures to carry out its duties. This will enable it to carry out its control and supervision responsibilities on all company actions successfully and efficiently.

One of the biggest industries in the world now is food, beverage, and tobacco. An essential component of a nation's economy is its stock market. The stock market is essential to the growth of the nation's industry and commerce, which has a substantial impact on the economy of the nation. The audit committee is viewed as essential because finance is becoming a bigger part of a company's overall growth strategy. Hence, the audit committee and company performance in listed Food, Beverage, and Tobacco firms in Sri Lanka for the fiscal years 2015–2020 are examined in the study. The food, beverage, and tobacco sector is one of the most significant sectors, with export revenue expected to reach \$7401.48 million USD in 2020 and an average growth rate of 6.4%. This is because it has the potential to benefit the economy greatly in terms of exchange earnings, suitable employment opportunities, innovation in the food system, improvement of the rural economy, and playing a significant role in local economies. However, the Sri Lankan food, beverage, and tobacco industry has encountered challenges such as high production costs, heavy investment costs, difficulty

for SMEs in this industry to secure international loan terms, and high interest rates in Sri Lanka. Hence a performance assessment system is essential for determining strategy, paying administration, and measuring the success of a company's goals.

The majority of factors, including capital structure, working capital management, inventory management, and others, have an impact on an entity's success in Sri Lanka. These effects have been thoroughly investigated in Sri Lanka over a long period of time by numerous researchers. But in addition, the performance of a business is also impacted by the Audit Committee. However, a few research on this topic were conducted globally as well as in Sri Lanka. Specially the effect of the Audit Committee on company performance the study of listed food, beverage, and tobacco industries in Sri Lanka. Hence this research study investigated the impact of the audit committee on firm's performance.

02. LITERATURE REVIEW

Audit Committee

The Institute of Chartered Accountants (CICA, 1992) defines the Audit Committee as " An organization's annual financial statements are examined by a board of director's committee before being presented to the board of directors. The committee serves as an intermediary between the auditor and the board of directors, and its tasks include examining the auditor's appointment, the audit's overall scope, the audit's results, internal financial controls, and financial information for public exposure."

Financial Performance

A company's performance can be assessed using a variety of ratios. Schiuma (2003) analyzed accounting-based performance using three different metrics: return on assets (ROA), return on equity (ROE), and return on investment (ROI) (ROI). These are frequently used to assess how well businesses are performing. Although more complex techniques like IRR, CFROI, and DCF modeling have been developed, ROE has shown to be a practical strategy. It emphasizes the company's dividend payout to shareholders, but it can also mask a number of possible problems. Companies can artificially maintain a good ROE and cover up deteriorating business fundamentals by using financial strategies. However, ROA eliminates the chance that financial strategies could lead to distortions.

Another indicator for assessing a company's financial performance is the Tobin's Q ratio. It is calculated by dividing the market worth of the business by the assets' replacement cost.

Audit Committee Size

The small number of audit committee members may be beneficial in impacting financial performance because they are more focused on discussing important financial concerns encountered by a company. (Lin, 2006) asserts that the size of the audit committee has a significant effect on the financial performance of the company.

(Al-Matari, 2012)) states that smaller audit committees are better at safeguarding the interests of shareholders and guaranteeing the accuracy of financial information.

Audit Committee Independence

The independence of the board of directors will enable the members of the audit committee to carry out their supervisory duties in an appropriate manner. According to a prior study, including outsiders on the audit committee can increase the company's quality and transparency of information by reducing data fraud and reducing managers' opportunistic behavior (De Vlaminc, 2015).

Audit Committee Meetings

Meetings are a useful tool for discussing and finding solutions to the challenges and issues that businesses face. Williams (1994) identified the number of meetings held by the audit committee as a measure of the effectiveness of the committee. As a result, the more meetings held, the greater signal for audit committee members in accomplishing their goals, according to (Bédard, 2010).

Agency Theory

Agency theory provides a valuable framework to understand the incentives and motivations behind earnings management and the role of audit quality in mitigating these issues. By aligning the interests of principals and agents, high-quality audits can help to reduce agency costs and promote efficient corporate governance. As such, policymakers, regulators, and investors should prioritize improving audit quality and enhancing transparency in financial reporting (Watts & Zimmerman, 1986). Agency theory refers to ideas and concepts that explain the relationships and interactions between various parties involved in corporate decision making, particularly between the principal (i.e., shareholders) and the agent (i.e., management).

Stewardship Theory

Agents are self-centered and individualistic, managers are concerned with the owners' well-being and the success of the organization, according to Stewardship Theory (Donaldson & Davis, 1991). The idea goes that managers will do whatever it takes to

fulfill the objectives of their shareholders (Boyd, 2011). According to (Hutchinson, 2009), if CEOs are given more authority and are trusted to run the business, firm performance will increase. The idea is that a committee with a majority of executive directors will function better and produce better outcomes than one with a majority of independent directors (Al-Mamun, 2014).

Stakeholder Theory

The Agency Theory has drawn criticism for merely offering a short-term perspective and an explanation of a firm's objective (Freeman, 1984). An alternative to agency theory is stakeholder theory, which is described, for instance, by (Abbott, 2002) as ensuring the terms of responsibilities to various stakeholders in order to create value and coordinate management levels among various stakeholders, including stockholders, employees, customers, creditors, suppliers, competitors, and even the entire society.

Institutional Theory

Institutional theory refers to the methods by which frameworks like standards, timetables, and recommendations become incorporated into the core principles of social policy (Richard, 2004).

The concept is relevant to the study since Kenya's environment for manufacturing businesses can significantly affect their financial success, usually much more than market factors. As a result, in order to guarantee good performance, the audit committee should check the applicability and compatibility of the accounting policies used for financial statements and the company's environment.

Resource Dependency Theory

The Resource Dependency Theory emphasizes the connection between organizations and their surroundings by looking at how external resources affect an organization's behavior. Resources are contributed by the board members, and the composition of the board directly affects the board's capacity to provide resources to the organization. According to Lawrence and Lorsch (1967), the resource dependency theory and corporate governance are related. It ties to Pfeffer's (1972) statement that board size and composition is a reasonable response to external constraints because successful organizations have internal structures that meet environmental demand.

03. METHODOLOGY

Resign Design

The two most popular types of research methods are quantitative and qualitative. The quantitative approach encompasses all techniques used to gather,

assess, evaluate, and summarize study data. whereas the focus of the qualitative research approach is the subjective evaluation of attitudes, beliefs, and behavior A quantitative method is considered to be an appropriate strategy for the investigation because numerical and secondary data are utilized.

Conceptualization.

The audit committee is viewed in this context as an independent variable, while firm performance is viewed as a dependent variable. The conceptual framework for the researcher's study is shown in Figure

Sample of the study

As of January 1st, 2023, the CSE had 290 companies, encompassing 19 different economic sectors. The study's sample was selected using a systematic random sampling technique from 30 out of 47 companies listed on the Colombo Stock Exchange in Sri Lanka's food, beverage, and tobacco sectors. The information is gathered over the course of five years, from 2017 to 2021.

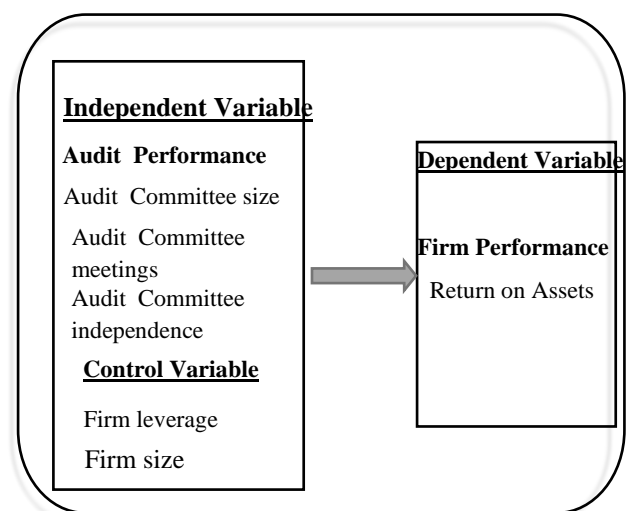


Figure - Conceptual Framework

Data Collection and Methods of data analysis

The majority of academics have conducted their analyses using secondary data from the companies' annual reports using the information offered by the literature. Also, this study is based on secondary quantitative data that was gathered from 2017 to 2021 throughout a five-year period. Data is gathered from secondary sources, mostly from the Company's annual reports of Listed Companies in Sri Lanka's Food, Beverage, and Tobacco industry, in order to achieve the study's objectives.

Regression analysis, correlation coefficient analysis, and descriptive statistical methods are used to analyze secondary data in order to achieve the study's goals.

The ratios in the model can be examined statistically using SPSS software

Hypotheses Development

An unproven statement on the connection between two or more variables is referred to as a hypothesis. This hypothesis is created for the study.

H: There is a significant impact of audit committee size on firm performance.

Hb: There is a significant impact of audit committee on ROA.

Hb1: There is a significant impact of audit committee size on ROA.

Hb2: There is a significant impact of audit committee meeting on ROA.

Hb3: There is a significant impact of audit committee independence on ROA.

04. RESULTS AND DISCUSSIONS

Descriptive Statistics

The table 01 presents the descriptive statistics for six variables based on a sample of 150 observations. The first variable is Audit Committee Size, which has a minimum value of 2 and a maximum value of 5. The mean value is 3.22, which suggests that the typical firm in this sample has an audit committee size of around 3 members. The standard deviation is 0.826, which indicates that there is some variability in the data.

The second variable is Audit Committee independent, which also ranges from 2 to 5. The mean value for this variable is 2.65, indicating that, on average, the firms in the sample have a moderately independent audit committee. The standard deviation for this variable is 0.696. The third variable is Audit Committee Meeting, which has a wider range, from 1 to 19 meetings. The mean value is 5.05, suggesting that the typical firm in the sample has about 5 audit committee meetings per year. The standard deviation is relatively high at 2.764, indicating that there is significant variation in the number of meetings across firms in the sample.

The fourth variable is Firm Leverage, which has a range of -15.20 to 79.76. The mean value is 1.6017, which indicates that, on average, the firms in the sample are not heavily leveraged. The standard deviation is relatively high at 6.90473, indicating that there is significant variation in leverage across firms.

The fifth variable is Firm Size, which has a relatively narrow range from 8.54 to 10.60. The mean value is 9.6390, indicating that the firms in the sample are, on average, relatively similar in size. The standard deviation is 0.45379.

The final variable is Return on Assets which has a minimum of -0.34 in ROA, indicating that some firms experienced a loss relative to their assets. And maximum of 1.37, showing that some firms had a return of 137% on their assets. The mean of 0.0948, suggesting that, on average, firms in the dataset had a 9.48% return on their assets. 0.17481 of standard deviation reflecting the variability of ROA across firms. A higher standard deviation indicates more variation in how effectively firms use their assets to generate profit. 0.031 of variance is the square of the standard deviation, further quantifying the spread of ROA values in the dataset.

Table 1. Descriptive Statistics

	N	Min	Max	Mean	Std. Deviation	Variance
AC S	150	2	5	3.22	0.826	0.683
ACI	150	2	5	2.65	0.696	0.485
AC M	150	1	19	5.05	2.764	7.642
FL	150	-15.2	79.76	1.6017	6.90473	47.675
FS	150	8.54	10.60	9.6390	0.45379	0.206
RO A	150	-0.34	1.37	0.0948	0.17481	0.031
N	150					

Source: Author Compiled

Corelation Analysis

The correlation between Audit Committee Independent and Tobin's Q is negative and moderately strong (-0.120), but also not statistically significant at the 0.05 level.

This suggests that the level of independence of the audit committee is not strongly related to a firm's value, as measured by Tobin's Q. The correlation between Audit Committee Meetings and Tobin's Q is positive and moderately strong (0.042), and statistically significant at the 0.05 level. This suggests that the number of meetings held by the audit committee is positively related to a firm's value, as measured by Tobin's Q.

When considering the relationship between the independent variables and Return on Assets (ROA), which is a measure of profitability. The correlation

	ACS	ACM	ACI	FL	FS	ROA
ACS	1	.242**	.637**	-0.034	0.129	0.074
ACM	.242*	1	0.037	0.020	.231*	-.174*
ACI	.637*	0.037	1	-0.116	-0.129	-0.071
FL	-0.034	0.020	-0.116	1	-0.021	-0.017
AS	0.129	.231**	-0.129	-0.021	1	.186*
ROA	0.074	-.174*	-0.071	-0.017	.186*	1
**. Correlation is significant at the 0.01 level (2-tailed).						
*. Correlation is significant at the 0.05 level (2-tailed).						
c. Listwise N=150						

between Audit Committee Size and ROA is positive but weak (0.074), and not statistically significant at the 0.05 level. This suggests that the size of the audit committee is not strongly related to a firm's profitability, as measured by ROA. The correlation between Audit Committee Independent and ROA is negative but also weak (-0.071), and not statistically significant at the 0.05 level. This suggests that the level of independence of the audit committee is not strongly related to a firm's profitability, as measured by ROA.

The correlation between Audit Committee Independent and ROA is negative but also weak (-0.071), and not statistically significant at the 0.05 level. This suggests that the level of independence of the audit committee is not strongly related to a firm's profitability, as measured by ROA. The correlation between Audit Committee Meeting and ROA is negative and moderately strong (-0.174), and statistically significant at the 0.05 level. This suggests that the number of meetings held by the audit committee is negatively related to a firm's profitability, as measured by ROA.

Based on the correlation table, it appears that the number of meetings held by the audit committee is the independent variable that is most strongly related to both Tobin's Q (positively) and Return on Assets (negatively), while the size and independence of the audit committee do not show a strong relationship with either of these dependent variables. However, it's important to note that correlation does not imply causation, and further analysis would be necessary to establish causal relationships between these variables.

Table 2. Corelation Analysis

Source: Author Complied

Regression Analysis

Regression analysis is a statistical technique that is used to determine the relationship between two or more independent variables and dependent variables. A correlation analysis does not identify a cause-and-effect relationship between the independent and dependent variables in this study. In regression analysis, several methodologies for modeling and evaluating variables are used.

Impact of audit committee on return on assets

$$ROA = \beta_0 + \beta_1 *ACI + \beta_2 *ACM + \beta_3 *ACS + \beta_4 *FS + \beta_5 *FL + \varepsilon$$

The Table 03 Model Summary provides information about how well the independent variables (predictors) explain the dependent variable (ROA) and whether the model is a good fit for the data.. In this case, R = 0.337, indicating a weak positive correlation between the independent variables and ROA. R Square is the proportion of the variance in the dependent variable that can be explained by the independent variables. R Square = 0.114, indicating that only 11.4% of the variation in ROA can be explained by the independent variables included in the model. Adjusted R Square is a modification of R Square that takes into account the number of independent variables in the model. Adjusted R Square = 0.083, which is lower than R Square, indicating that the model may be overfitting the data and may not generalize well to new data.

The Std. Error of the Estimate is the standard deviation of the residuals, which represents the amount of error in the model. The smaller the value, the better the model. In this case, the value is 0.16741, indicating that the model has a moderate amount of error. Durbin-Watson statistic tests for the presence of autocorrelation in the residuals (i.e., whether the residuals are correlated with each other). A value between 0 and 2 indicates no autocorrelation, and a value closer to 2 indicates no or weak positive autocorrelation. In this case, the value is 1.362, which is within the acceptable range.

Table 3 Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.337a	0.114	0.083	0.16741	1.362

Source: Author Complied

Table 04 Anova shows regression Sum of Squares represents the amount of variation in the dependent variable that can be explained by the independent variables in the model. In this case, the regression sum of squares is 0.518. And the Residual Sum of Squares represents the amount of variation in the dependent variable that cannot be explained by the independent variables in the model. In this case, the residual sum of squares is 4.036. Total Sum of Square indicates the total amount of variation in the dependent variable. In this case, the total sum of squares is 4.553.

Mean Square is the sum of squares divided by the degrees of freedom. It represents the average amount of variation in the dependent variable that can be explained by the independent variables (in the case of the regression mean square) or cannot be explained by the independent variables (in the case of the residual mean square). F statistic tests whether the regression mean square is significantly different from the residual mean square, which would indicate that the model is a good fit for the data. In this case, the F statistic is 3.694, with a significance level (Sig.) of .004, indicating that the model is a good fit for the data

Table 4 Anova

ANOVA ^a						
Model		Sum of Square s	df	Mean Squar e	F	Sig.
1	Regression	0.518	5	0.104	3.694	.004 ^b
	Residual	4.036	144	0.028		
	Total	4.553	149			
a. Dependent Variable: Return On Assets						
b. Predictors: (Constant), Firm Size, Firm Leverage, Audit Committee Size, Audit Committee Meeting, Audit Committee independent						

Source: Author Complied

In table 05 Coefficient of ROA, Audit Committee Size, Audit Committee Meeting, and Firm Size have significant coefficients, as indicated by their p-values (0.035, 0.002, and 0.022, respectively). This means that these variables have a statistically significant effect on Return on Assets, holding all other variables

constant. However, the coefficients of Audit Committee independent and Firm Leverage are not significant at the 0.05 level, meaning that there is not enough evidence to suggest that these variables have a statistically significant effect on Return on Assets. The standardized coefficients indicate that the most important predictor of Return on Assets in this model is Audit Committee Meeting, followed by Audit Committee Size and Firm Size.

$$ROA = (-0.570) + (-0.047) * ACI + (-0.017) * ACM + 0.049 * ACS + 0.074 * FS + (-0.001) * FL + \varepsilon$$

The equation estimates that, holding all other independent variables constant, for every one-unit increase in ACIND, ROA is expected to decrease by 0.047. Similarly, for every one-unit decrease in ACMEET, ROA is expected to decrease by 0.017, and for every one-unit increase in ACSIZE, ROA is expected to increase by 0.049. For every one-unit increase in FSIZE, ROA is expected to increase by 0.074, while for every one-unit increase in FLEV, ROA is expected to decrease by 0.001. The constant term in the equation is -0.57, which represents the expected value of ROA when all independent variables are zero. The ε term represents the error term, which captures the variability of ROA that is not explained by the independent variables.

Table 5. Coefficient table of ROA

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-0.570	0.314		-1.814	0.072
	ACS	0.049	0.023	0.233	2.133	0.035
	ACM	-0.017	0.005	-0.268	-3.225	0.002
	ACI	-0.047	0.027	-0.188	-1.745	0.083
	FL	-0.001	0.002	-0.022	-0.272	0.786
	FS	0.074	0.032	0.193	2.307	0.022
a. Dependent Variable: Return On Assets						

Source: Author Complied

Hypothesis Testing

Hypotheses	Statistical techniques	P Value	Results
Hb: There is a significant impact of audit committee on ROA			
Hb1	Regression	0.035	Supported
Hb2	Regression	0.002	Supported
Hb3	Regression	0.083	Not Supported

Discussion on Impact of Audit Committee on ROA

The current analysis did not find a statistically significant association between the presence of independent non-executive directors in AC and business performance. Prior research on the relationship between the two variables revealed a negative relationship (e.g., Bhagat and Black, 2002; Dar et al., 2011; and Lin and Wang, 2010) and argued that independent directors have insufficient knowledge of the business, which could result in providing incorrect guidance to businesses, resulting in poor financial performance. Whereas, from an Agency Theory perspective, director independence appears to positively influence business performance, when considering other theories such as Resource Dependency Theory, there may be a negative association between independent directors in AC and firm performance. This is mostly due to the inability of independent directors to provide adequate support to enterprises, as described in studies such as Adams and Ferreira (2007), Harris and Raviv (2008), and Khosa (2010). (2017).

05. CONCLUSION AND RECOMMENDATION

The study came to the conclusion that three independent variables influence organizational performance. This study's main objective is to look into the effects of several audit committee characteristics, like committee size, independence, and meetings, on the financial performance of listed food, beverage, and tobacco companies in Sri Lanka as shown by return on assets. Return on Assets is significantly impacted by audit committee characteristics like audit committee size and audit committee meetings. Also, the size of the audit committee of Sri Lanka's listed companies. The study's findings for the Food, Beverage, and Tobacco companies imply that particular audit committee characteristics in Sri Lanka are pertinent to a company's success in terms of Return on Assets. Regulators in other jurisdictions who are searching for measures to improve the efficiency of the Audit Committee, overall firm governance, and investors' confidence in the firms may find the findings to be helpful.

The suggestions provided are valuable for future research in the area of Audit Committees. One

potential area of investigation is the impact of other committee attributes such as the size of the committee, individual characteristics of the directors serving on the committee, and the internal processes of the committee. Additionally, future studies could incorporate primary data or a combination of primary and secondary data to enhance the validity of the findings. Finally, a qualitative approach could be utilized to better understand the impact of Audit Committee attributes on the value relevance of accounting information.

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ABBREVIATIONS AND SPECIFIC SYMBOLS

ACS – Audit Committee Size
ACM – Audit Committee Meeting
ACI – Audit Committee Independence
FS – Firm's Size
FL – Firm's Leverage

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An assessment of Women's Representation in Planning and Decision-Making at the Executive level

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Abstract-Gender diversity in the planning and decision-making participation is essential for the economic, political, and social perspective of any society. Modern women are committing and working hard to gain respect and the status of the economy through certain feminine traits. This study focuses on examining the root causes behind the lack of women's participation in planning and decision-making positions at the executive level in Sri Lanka and proposes policy recommendations to overcome identified barriers. This paper used the qualitative method by reviewing the literature. As the key factors, the literature identified the influence of higher education, the role of legal structure and the influence of culture on the absence of women's dynamic participation in planning and decision-making positions. Generally, Sri Lankan females do not tend to enroll in academic streams that available plenty of job opportunities. Further, the legal structure of the government and particular organizations have no sufficient influence on women's decision-making positions, and lastly, the culture inversely affects to the women's participation in the decision-making positions as the grass-root factor. As the policy measures, the government should facilitate policies towards enhancing women's active participation through effective higher education policies and relevant policies to prevent the burden from cultural boundaries.

Women themselves should ensure their self-confidence and bend their qualifications to cope with job market requirements.

Keywords: Decision-making, Executive level, Planning, Policy, Women

I. INTRODUCTION

'Women hold up half the sky' says a phrase from China which signifies the importance of women's role in society. To be competent with men, women must be educated, socialized and supported by the legal framework of government or particular institute, and allowed access to opportunities and the influence of culture on the absence of (DAW), 2005). The statistics illustrate that the average literacy rate of women in 2018 reportedly increased to 90% from 76% in 1985 (UNICEF, 2019). However, women are still lagging behind in opportunities.

maker at the executive level coinciding with men, due to the 'glass ceiling effect' (Priyanwada, 2016). These shreds of evidence highlight the deficiency of gender diversity in planning and decision-making in top-tier positions.

many areas such as underrepresentation in politics, deprivation of access to the health, and limited opportunities in the labor market (Nations, 2020). Though the problem of women's active representation in society exists to many extents, this study mainly emphasis on women's representation in planning and decision-making at the executive level in Sri Lanka. The study only considers the executive level which is specialized in operating businesses instead of public administration to limit the scope of the study. Although women's academic performances are sufficient to be appointed as decision-makers, socially embedded values, beliefs, and norms are dragged drag women to subordinate positions. The International Labor Organization (ILO) (2016) has emphasized the

According to Jennifer et al., (2017), the gendermain factors that hinder women's gap in the labor market is continued with the women's substantial roles and responsibilities within the families, human capital mismatches when women do not have the skills and competencies required from the labor market, and discrimination in recruitments and promotion schemes. Hence, women's level of education, legal structure towards diversified gender participation, and social and cultural norms embedded in each country have been influenced to determine the level of female involvement in planning and decision-making in the executive level.

Education is considered as the most prominent factor of economic, political, and social development in any context. The trend of women's level of higher education has developed for years and currently, there are 53% of worldwide female graduates (UNESCO, 2020). Yet, the overall women's career advancement indicates a 'leaky pipe syndrome' because females only represent 28.25% at the executive level according to the worldwide data (Nations, 2020). In addition, instead of women, men are more interested in educational, extracurricular activities, media events, or political discussions, in schools or universities (Lawless Fox, 2013). Conversely, it is difficult to become a female decision-

participation in top-level planning including underrated women's performances, view of women as economic dependents, level of mortality, and so forth. Consequently, the main bottleneck is caused by the social expectations and stereotypes towards women. Even if there are many physical differences between men and women, societies should not only be dominated by men and each nation deserves to have a capable leader either man or woman without discriminating by the gender.

which needs immediate attention. Thus, this study aims to observe the main causes that discourage women's participation in planning and decision-making.

II. RESEARCH QUESTIONS

In order to promote women in the decision-making arena, countries have formulated and implemented certain rules, regulations, and customs towards gender equality and have provided a balanced participation in economic, political, and social activities through the legal framework. However, OECD (2020) declared that the majority of qualified women are still not representing their deserved positions even women are entitled to stand up against discrimination.

According to the Gender Gap Index (GGI), Sri Lanka has been spotlighted mainly due to the lack of women's participation in politics and economic activities (Global Gender Gap, 2021). The statistics revealed the manifestation of the problem in the participation of women in the decision-making in economic platforms. As a result, this study will mainly address the following questions.

What are the underlying reasons behind the low representation of women at the executive level?

What are the policy measures towards for improving representation at the executive level?

Women's access to education in Sri Lanka is at a notable level which explains the educational attainment in the global gender gap index 2020, Sri Lanka is at 88th place out of 153 countries (World Economic Forum, 2020). Apropos of the labor market gender gap tends to widen at the executive level. According to the statistics, 24.8% of executive level female representation in Sri Lanka was indicated in 2019 (UNICEF, 2019). Additionally, Gunawardena (2014), stated that the Sri Lankan economy has not yet been gender-balanced due to a male-dominated political culture inside of organizations that hinders women's career advancement to climb the executive ladder further.

In the context of Sri Lanka, for certain reasons, women are not yet leading the economy and politics as decision-makers and planners,

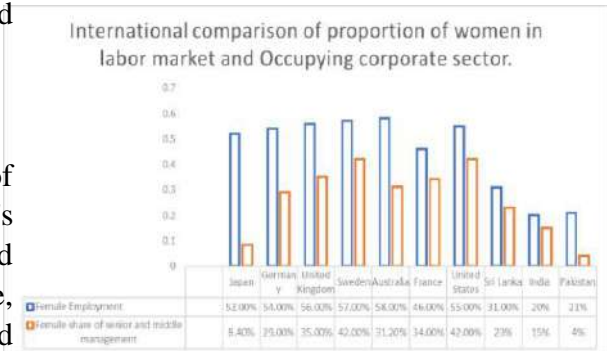
III. LITERATURE REVIEW

This section will review the literature explicated by several authors regarding women in planning and decision making at the executive level. At the end of the section, the conceptual framework will be constructed based on the literature.

Despite women are also part of the system of economic and cultural settings, women 's contribution to the economy is often unnoticed and underestimated (Sohail, 2014). Hence, women in the current world are dedicating and working hard to gain respect and the status of the economy through certain feminine traits.

sick benefits, types of contracts, lack of promotions and hours of employment than men due to inappropriate job segregation.

Thus, 'women end up in dead-end positions' or ones involving limited mobility (International Labour Organization, 2016).



To become an executive level employee, a greater capacity of management is required. The situational theory which was invented in 1930 has emphasized that women in management or corporate roles have a low profile and are not able to advance in management in a significant way (Jogulu Wood, 2006). But afterwards, the specific management styles originated and the role of women in the leading positions has been identified as democratic that more favorable to feminine traits compared to patriarchal characters.

Figure 1: Comparison of women on labor market and occupying in executive level

1

Women's under-representation as female managers has been caused by certain facts containing women choose not to hold high-level positions by themselves, work-family conflicts, and so on (Wambua, 2013). In addition, ILO (2016), explained that women are struggling in accessing specific job ladders compared to men, because of the separation of job roles between men and women who are affected by their domestic responsibilities, skills, payment, status and power (LIM, 1996 cited by International Labour Organization, 2016). Similarly, women are less advantaged with a lower payment, lack of pension and

According to the World Bank (2019) statistics, the current status of women in the overall employment to population ratio is steadily declining and the share of women in executive level participation is slightly different in each country. Both statistics are illustrated in selected developed and developing countries as follows.

in the administrative sector compared to men is that men are more qualified than women, especially in promotion based on skills. Due to several cultural norms and social myths, the majority of women are not allowed to enter the administration and other fields as decision-makers, even though they are qualified with education. Hence, higher education is not the only factor that determines the level of female participation at the executive level as decision makers.

According to these statistics, the developed nations other than Japan reflect a higher tendency in participating executive level positions compared to the total female employment ratio. But in developing countries, the participation of women in the labor force and the executive level is relatively low.

Sri Lanka's progress in educational attainments is remarkable because it surpassed the regional averages of developing countries (Gunewardena, 2015). That impressive educational success of women has not shown in economic and political opportunities in Sri Lanka, and thus, the participation rate of the Sri Lankan female workforce stagnated at about 35% from 2009 to 2017, compared to a stable male ratio (75%) at that

A. Education

Education is considered a significant factor in both development of nations and human capital. The human capital theory by Becker, 1994 cited by Khatwani (2018), explains that education expands the efficiency of a person by improving an individual's skills, knowledge, and competencies, and it influences the access to the decision making process in the family, community, and national level. The study by Khatwani et al., (2018) found that higher education creates consciousness among women to shorten their dependency, raise their physical and social mobility, unlock job opportunities, and enhance the confidence and self-reliance of women.

The study of Vincent-Lancrin, (2008), revealed that while women's higher education is on the rise, there are significant differences in decision-making levels, such as the different salaries of men and women in the executive level and the biased recruitment process for top management positions. Dorsy, 1989 cited by Wambua (2013) also found that one of the main traits of the low representation of women

women, especially in decision-making positions.

time (IFC, 2019). Primarily, women prefer public sector jobs that tend to offer family-friendly benefits, steady working hours, maternity leave, and other benefits (IFC, 2019). Thus, the majority of female graduates are in the unemployment pool until the government offers them a job in a public sector, and their employment choices are limited to the lower level which is misaligned with their level of education.

B. Legal structure

Typically, women are restricted by particular social, legal, and institutional difficulties due to the burden of work-family responsibilities, gender stereotypes around women at the workplace, lack of female role models, glass ceiling effect, and lack of opportunities to network (OECD, 2020). As the first step, most of the countries follow paid parental leaves leave in terms of protecting women's career prospects. In addition, minimum quota rules² for women at the executive level, company-level diversity policy for senior management, provisions on gender at the executive level, and especially family-friendly workplace regulations have been formulated to minimize discrimination against women (OECD, 2020).

OECD report (2020) pointed few examples of the best practicing legal structures at the executive level to promote gender diversity, for instance, Canada's "Gender Results Framework (GRF) in 2018 and "Gender-Based Analysis Plus" (GBA+) since 1995 to incorporate a cross-cutting gender perspective, Japan's act on "promotion of female participation and career advancement" enacted in 2015, and United Arab Emirates' (UAE) the gender-balanced council which was established in 2015. Correspondently, every country should have an expansive policy vision to prevent discrimination against

C. Social and Gender norms

Social and cultural norms were accepted in the Sri Lankan context and strongly influenced the employment of women and especially, in

The difference between the workplace and decision-making positions. Women are often family life must be clearly understood in every less likely to remain in the workforce after aspect to ensure the professional advancement marriage and childbirth due to inflexible work of women. Social role theory which addresses regulations and family pressures. gender differences has revealed that social. Consequently, women's less representation norms are the key factor in initiating the restricts the presence of the female voice in division of labour (Priyanwada, 2016). This important decisions at the executive level and theory preliminary preliminarily assumes that political arena.

women are often inferior in occupations and a woman is strong enough to balance dual careers with family life and workplaceIV. METHODOLOGY
conflicts. Such theories have been developed to reflect deeply embedded social and gender

stereotypes. Geert Hofstede's cultural theoryThe study carried out with qualitative also emphasizes that culture is created by methodology reviewing the literature. The combining values, norms, and social secondary data referring scholarly articles, relationships (Priyanwada, 2016). The theory theories, data and statistics were used to is clearly expressed by key dimensions analyse the results including world bank data, separately such as cultural bias, social International Labor Organization, University relations, and the way of life. People living in Grant Commission reports, gender gap index a male-dominated society deeply think that reports along with books and journal articles. men are intelligent and work-oriented and The study was based on analytical research as women are more likely to engage in domestic it tried to find out the work. However, both men and women should be respectful and share their responsibilities and duties instead of social or gender norms which are sympathetic to one part of society.

The concept of "Broken rungs" explains the causes that hinder women from achieving executive-level positions and remaining at entry-level positions for a long time (McKinsey, 2019 cited by OECD, 2020). The author has arrayed factors such as slow turnover of board seats, non-transparent selection criteria, and informal appointments based on male-dominated networks. As Wambua (2013), argued due to socially distributed descriptive and prescriptive norms, existing gender roles, and stereotyped social behaviors have emerged.

reasons for the lower participation of women in the planning and decision making stage.

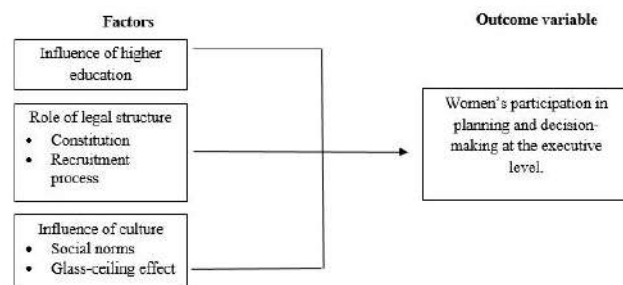
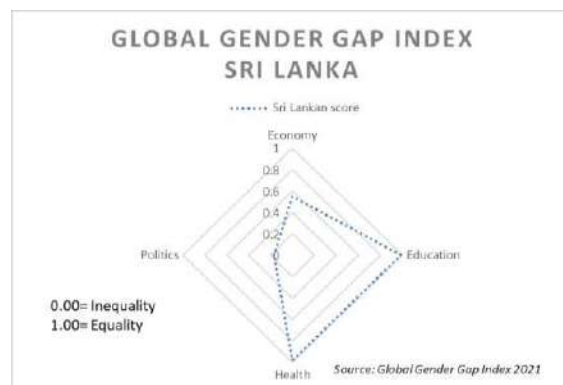
country (World Economic Forum, 2021). The GGI of Sri Lanka in 2021 has is illustrated with the equally-weighted sub-indexes as follows.

V. ANALYSIS AND DISCUSSION

Figure 2: Global Gender Index in Sri Lanka

This section will analyze the main reasons that hinder women's active engagement in planning and decision-making in the executive level in Sri Lanka, under the variables identified through the literature review.

The main research problem in this study is highlighted in this widen gender gap in politics and the economy as it has been delimited the sound of women compared to health and education. Under the economic dimensions, an increase in the gender gap in the economy, the number of senior and other executive level officials and salary equality are the main measures of the level of the gender gap (World Economic Forum, 2021). The key causes that determine the level of women's participation in



Sri Lanka is a South Asian country with various ethnic, religious, and cultural backgrounds. Women and men represent 52% and 48% of the population respectively, indicating a steady decline in the male population and a steady increase in the female population over the years (World Bank, 2019). However, in 2006, Sri Lanka was in 13th³ place in the Gender Gap Index, and in 2021, Sri Lanka is was in 116th place out of 153 countries signifying the largest rank declined



decision-making and planning will be discussed henceforth.

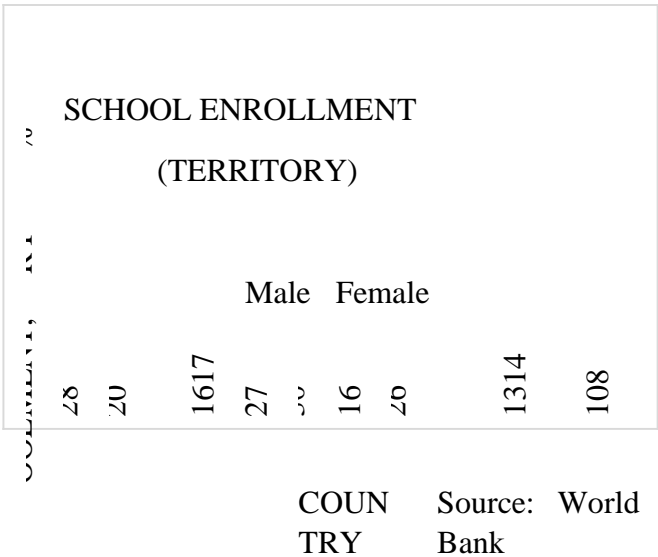
VI. ANALYTICAL FRAMEWORK

This study will have an analytical framework associated with three variables that lead to influence the level of female participation in planning and decision-making. These factors are identified as boys than girls. Although Sri Lanka faced a civil war higher education, the role of legal structure in both for almost 30 years and reduced the spending on politics and the executive level, and social and cultural norms.

According to this graph, Sri Lanka has a considerable gap in 2019 in school enrollment between males and females in the South Asian region. Aturupane, et. al (2018) revealed that there is a trend of widening gender disparity in educational representation in middle and high-income countries and the dropout trend in higher education is more likely to be for almost 30 years and reduced the spending on education to increase military expenses, the country still reflects a notable improvement in educational attainments.

Influence of Higher Education towards the executive level

Sri Lanka has ensured a non-discriminated higher education policy since 1945 as free education policy (Gunawardena C., 2003). Consequently, a gender-balanced educational opportunities in Sri Lanka were have widened and developed. Hence, the country has a remarkable increase in educational achievements by females across the South Asian region, and especially, Sri Lanka is the only South Asian country that successfully achieved gender equality at all levels of education in the Millennium Development Goals (MDGs) (Silva, 2018).



Trend of University Enrollment in Sri Lanka, 1942/43-

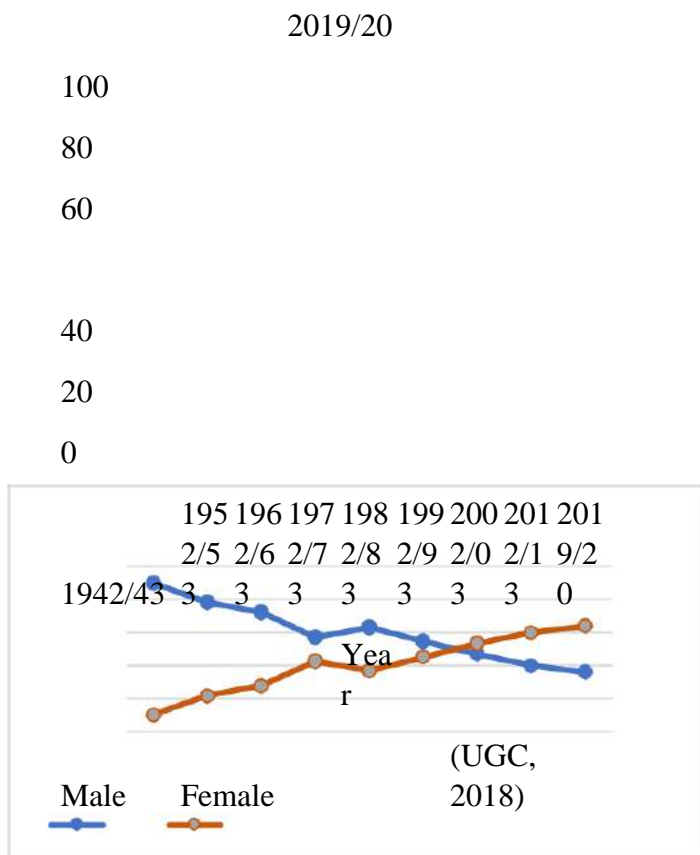


Figure 4: Trend of University enrollment in Sri Lanka

According to the chart, female university enrollment was very low at the beginning compared to male enrollment. However, after 2002/03 academic year, female enrollment was gradually increased when male enrollment decreased over the period. This steady increase was directly affected by the free education policy enacted in 1947 and the gradual growth of the female population (Wickramagamage, 2012). The government has taken certain actions to have a gender balance in each sector and education is in the first place compared to other sectors. But female enrollment in engineering, technology, and architecture streams is at a lower level compared to the other academic streams and women have failed to make headway on these streams for a long time (Gunawardena C., 2003). The following chart illustrates the composition of university enrollment by gender compared to the years 2010, 2015 and 2019. The chart clearly indicates that engineering and art

streams have a higher gender difference compared to other academic streams.



Figure 5: Composition of total undergraduate enrolment

Generally, the opportunity to access education has not given equal chances to select courses (Gunawardena C., 2003). The main reason for the lower level of academic performance of women in such disciplines is caused with cultural beliefs about women's ability and strength, fear of female students to follow such courses, family influences,

and heavy academic preparation (Meiksins, Layne & Beddoes, 2019).

The female engineers in the labor market reflect with

9% due to certain cultural influences, societal pressures, and family challenges (Wahid, 2020). A majority of female graduates enrolled in the arts, commerce and management streams. Among the unemployed graduates, 83% of the majority are female graduates, and there is a higher unemployment rate among graduates created by the arts and performing arts streams (UGC, 2018). The

report further found the reasons for inadequate female decision-making positions in the executive

level as mainly due to the non-availability of female

candidates with d , and 40

mismatches between skills possessed by graduates 0

and skills required by employers. 20

As per the University Grant Commission (UGC),

female graduates d 67.8% of state

universities in 2018, more than twice as male graduates (32.2%) (UGC, 2018). Although

higher studies and women's recruitment to executive level positions. Further, the main recruitment factors

in Sri Lanka identify with the social norms, the role education expands employment for both men and

of women balancing gender diversity and the

substives in reality. According to the UGCs (2018), (Markel et al., 2016). With all these factors, the

full employment status of the gap between female The educational streams and will illustrate participation follows at executive level.

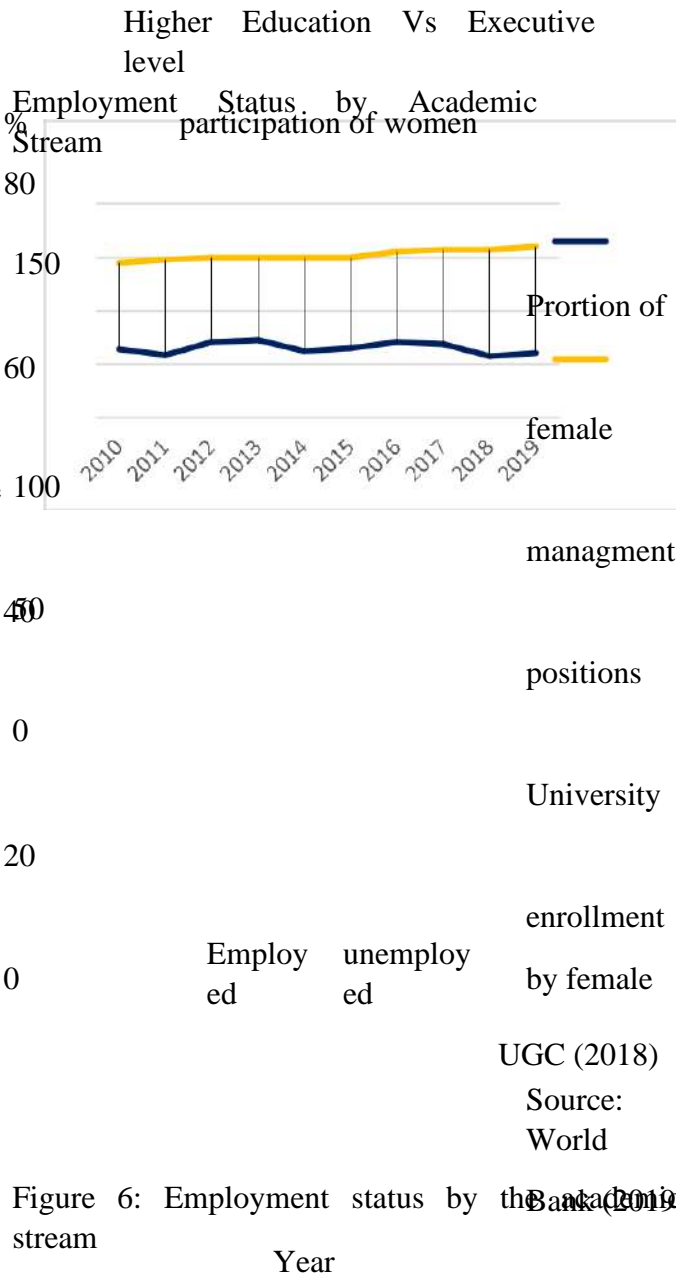


Figure 6: Employment status by the Bank (2019)

In this figure, the arts and performing arts streams

where more females have been admitted to the

universities, represent the majority of

unemployment. The academic streams where a

minor enrollment of females has been enrolled

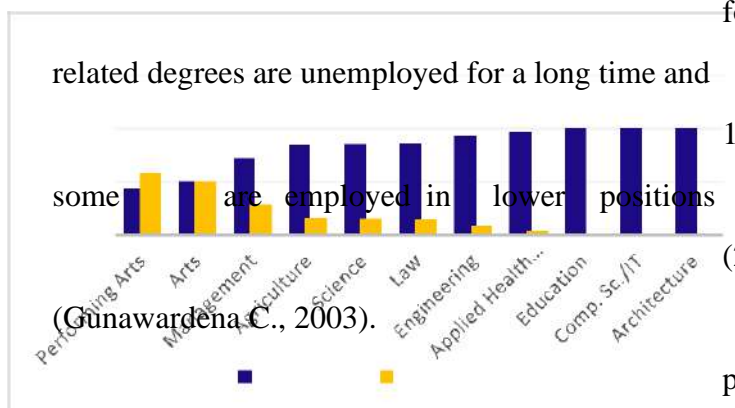
represent a ratio. As a result,

educated women who are highly enrolled in arts-

related degrees are unemployed for a long time and

some are employed in lower positions

(Gunawardena, 2003).



Women comprise 27.58% of managerial

positions in the executive level in 2017 (UNICEF,

2019), which indicates a marginal power towards

women. According to the statistics, there is a

significant lag between female graduates from

by law, regulations, or administrative action for the

advancement of women” (Justice, 2016), however,

the modifications of this law depend on the political

will of current politicians (Kodikara, 2008). As the

authorized institution to ensure equal and balanced

gender participation in society, the Ministry of

Women and Child Affairs was directed to

formulate development policies (Razavi Miller,

1995). The performance report of the ministry

(2017) observed that instead of implementing

projects and policies on health, education, rural

gender-development, and based violence, the

ministry has not formulated programs or policies to

enhance women’s decision-making participation.

Employed Population by Occupational

Groups, 2014

Certain provisions for female employees were declared legally containing the maternity benefits by ordinance no 32 of 1939, equal remuneration, maternity leaves, and service conditions entitled by labor legislation (ADB, 2015). Further, the Sri Lankan government agreed on international standards such as the International Labor Organization (ILO), and Millenium Development Goals (MDGs) to ensure women's equal participation (Marikar, 2019).

Certain best practicing countries follow clear policies and laws to recruit employees in a gender-balanced way. For example, Japan has adopted to gender equality policy and based on that policy, the 'Intensive policy to accelerate the empowerment of women' in 2015, 'The act on promotion of women's participation and advancement in the workplace' in 2016, 'The guideline to promote work-life balance in 2014 were formulated and enacted (Gender equality Bureau, 2017). In Sri Lanka, the highest decision-making positions of females were only 20% in 2011, and the gender segregation index for the administrative and managerial category gradually decreased over the last decade indicating a drop from 32.2% to 21.3% between 1996 and 2011 (Jayatilake, 2016). In this concern, Sri Lanka needs to adapt with transparent appointments, because women's commitments to leadership positions were blocked and not discussed in the legal framework (Marikar, 2019).

Due to Sri Lanka's deficiency in transparency and openness in the promotion and selection process, female employees are stuck in middle-level positions. Consequently, the majority of women were employed in teaching and nursing occupations where women only held 25% in Grade I in the Sri Lankan Administrative sector in the public sector, and only 6.1% of directors of boards in the private sector (ADB, 2015).

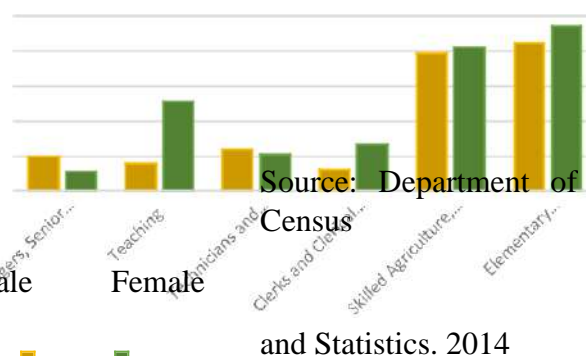


Figure 8: Employed population by occupational groups

As this figure shows, female employees mainly involve in lower-level of positions in the job hierarchy which has a lower potential to being promoted. The lack of appropriate laws and policies on the recruitment, and promotions of female decision-makers has increased the imbalance in women's participation at the executive level. Therefore as the general view, teaching and nursing professions are categorized as feminized employment, and at the same time, women are underrepresented in senior positions at the executive level (ADB, 2015).

C. Influence of culture towards the executive level

Sri Lanka has undergone certain internal conflicts for many years and women's human rights have not been implemented well due to the country's culture, patriarchal structures, and unsettled internal and external conflicts (Leyton, 2006). Therefore, women do not actively engage in politics and decision-making positions at the executive level. In this section, the author will discuss how women are restricted by cultural factors in order to participate at the executive level. As the sub-factors under the culture, the social norms and the glass ceiling effect in Sri Lanka will be explained.

which ensure the work-life balance according to the norms. Wambua (2013) identified culture as an external factor in determining who has the potential to be in decision-making positions. Thus, only one-third of executive level positions are held by women in Sri Lanka, though they nearly represent one-half the workforce (Marikar, 2019).

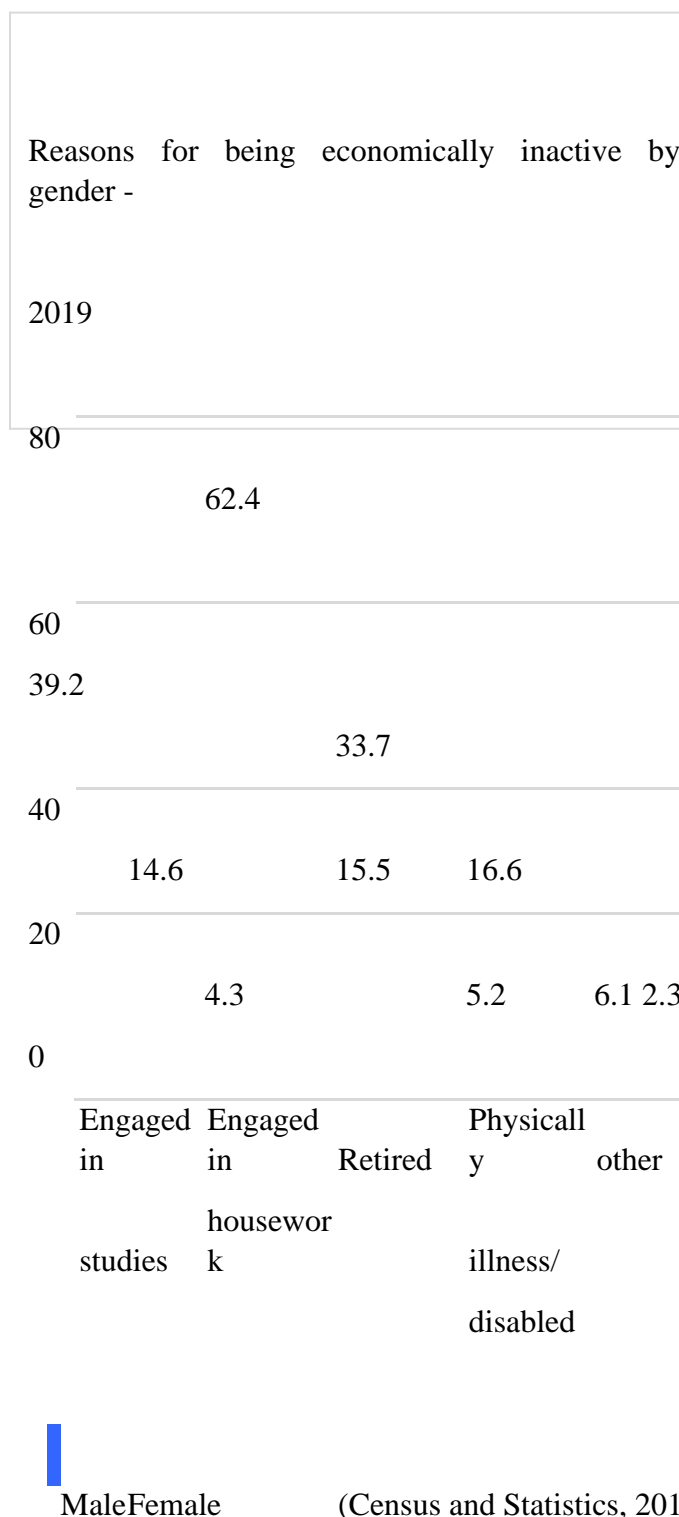
Traditional Sri Lankan marriages are a benchmark for declining female labor force participation. Because, society has prearranged the roles and social values of women within the households and restricted the advancement of their careers (Jayatilake, 2016). By relying on that statement, the probability of being out of the workforce or ignored by the executive level is higher for women who are married and have at least one child (Chowdhury, 2013). Sri Lankan norms were adapted to assume

Influence of social norms on the executive level participation

According to the Sri Lankan social norms, men are stereotypically identified as independent, work-oriented, and householder, while women are dependable and responsible for household activities (Jayatilake, 2016). Hence, women are expected to perform as men at the executive level and adapted to predetermined masculine traits and norms. Sri Lankan culture plays an important role in choosing careers for both men and women and traditionally, females from childhood are encouraged to select teaching or nursing jobs

that men were more likely to hold corporate positions than women, as women were generally believed to be emotional and sensitive by birth (Priyanwada, 2016). According to the annual report of the Department of Census and Statistics (2019), the main reason for the majority of women's absence in economic participation is their earnest involvement in household activities (62.4%).

Figure 09: Reasons for being economically inactive by gender



Priyanwada (2016) found that in many countries, the executive level has traditionally been managed by men with their predefined practices, values, and culture where women are assigned the responsibilities of the family. Hence, employers have a strong preference towards male employees (Gunawardena, 2003). Under the social norms, discrimination among genders, family-life demands, and prejudice hinder women's participation in decision-making activities. The opinion that women are more sensitive leads to reduced equal opportunities for career development and greater mobility of women in organizations (Priyanwada, 2016).

Both males and females have several different patterns in the way of their decision-making and involvement in executive level matters. Generally, male counterparts focus on the task, while females are more intended to emphasize the people (Rincón, González & Barrero, 2017). Thus, organizations should empower women to make effective decisions without relying on societal norms and beliefs about women.

Influence of the glass ceiling effect on the executive level participation

The concept of the 'glass ceiling effect' explains the difficulty for women to be promoted to high-level positions and the difficulty of being stuck in lower or middle-level ranks. This invisible barrier does not imply clear discrimination against women, but different policies, goals, and attitudes may exist without deliberate discrimination in the workplace

(Kuruppuarachchi & Surangi, 2019). In Sri Lanka, women seek indirect actions such as work from home, leaves, and comfortable working hours because they give more priority to their families. As a result, the investment in education and training becomes less beneficial and these behaviors of women will be continued for a longer time. Glass ceiling effect may have a direct or indirect connection with cultural and traditional features on restricting women's career progress in Sri Lanka (Priyanwada, 2016).

As per the identification of reasons that hinder women's engagement at the executive level, the level of education directly influences to women's representation in decision-making positions, however, the Sri Lankan females do not tend to enroll in more influential academic streams. The legal structure of the government and particular organizations have no sufficient influence on women's decision-making positions, and lastly, the culture affects the women's participation in the decision-making positions as the grass-root factor in Sri Lanka.

Kuruppuarachchi and Surangi (2019) explained the glass ceiling effect by categorizing it into three factors such as personal barriers, organizational barriers, and societal barriers. Under the personal barriers, Sri Lankan women's career development may be hindered by their preference of risk opposed jobs, and self-rejection which reduces women's confidence and family responsibilities⁷ which diminishes women's time, energy, and availability to work (Kuruppuarachchi & Surangi, 2019). The author explained the organizational barriers as, lack of transparency in the promotion scheme, the tradition of lengthy working hours, lack of support from work colleagues and top management, and unfair criteria of performance evaluation. The societal barriers explain social environment pressure that comes from religion, education, technology, culture, residential and financial background, and secondly, the matter of gender which is identified by occupational fitness, and career knowledge (Kuruppuarachchi & Surangi, 2019).

In addition, women's career ambitions for decision-making positions may be affected by socioeconomic background, race, education level, parent's occupation, and family background, consequently, Sri Lankan women are paid a lower salary and there is a higher probability of women that left their profession in midway as an outcome of glass ceiling effect (Damunupola & Suthab, 2019).

VII. POLICY RECOMMENDATIONS AND CONCLUSION

diversity at the executive level (IFC, 2019). As the main barrier, the rising fertility rate reduces female employment in the labor market. Thus, as a policy, the government should formulate legal bounds to enable women to remain or return to the labor market with flexible working arrangements (Gunathilaka, 2013). The author further explained that developing new technology, infrastructure, telecommunications, and other necessary equipment to operate a safe and efficient transportation system and facilitating an online working culture would be an effective strategy to retain women employees at the executive level. Several best-practicing countries follow outstanding policies and laws to maintain a gender balance in the labor force. Sri Lanka must adopt the most committed laws at the international level, especially laws on the prohibition of employment advertisements and the enactment of recruitment that the facts to discourage or prejudice on religion,

In the previous section, the reasons and difficulties behind the underrepresentation of women in decision-making positions were discussed. In this section, flexible policy recommendations will be presented to overcome the struggles faced by women at the executive level.

According to the evidence discussed, lower-level of female employment at the executive level is represented though there is a majority of well-educated females. Thus, it clearly reflects a gap between the economy and socio-cultural levels. Beyond the graduate level, investment in skill training is inspiring women to engage in decision-making positions. The students who are not continuing their education should be provided with job-oriented technical and vocational training (Gunathilaka, 2013). One of the main criticisms of university education is “low standards and a majority of female students enrolled to social science and humanities (Art faculty) which is the field that difficult to find a productive employment” (Kanagasingam, 2015, P.187). As a remedy, the government should formulate an awareness program at the provincial level to develop the relevant knowledge and skills to manage labor market aspirations and support economic growth as a whole. Apart from educational qualifications, to become a policy-maker in the executive level, the ability of effective communication skills, interpersonal skills and conceptual skills, proactive realistic thinking, computer literacy, the ability of logical and rational thinking, personal hygiene, and social etiquette

should be developed through education (Kanagasingam, 2015).

Organizational structure, recruitment process, performance evaluation, and promotion scheme should be organized in a gender-friendly manner to maintain a balanced gender

Development Bank, ISBN 978-92-9257-024-8 (Print), 978-92-9257-025-5 (e-ISBN).
 race, and sex plus gender identity and pregnancy (U.S. Commission, 2020).

According to the Sri Lankan culture, married women object to household constraints such as child care, elderly care, and other similar responsibilities. The collection of these beliefs, values, customs, and social norms imposed by the culture will interrupt the women's career development. As policy suggestions, family-friendly policies encourage sharing household and societal burdens between men and women, and secure environments with effective maintenance of law and order for women to travel, because Sri Lankan women are more vulnerable to being sexually harassed in public transportation (Gunathilaka, 2013). The author further suggested in order to decrease prevailing gender inequalities from the executive level, legal and institutional policies should be strengthened to discourage sexism and gender stereotyping in the labor market. Those legal provisions should include the limitation of hours granted to work for women, mandated transport policies for women who work in the nighttime, and maternity leave provisions (Mendis, 2013). In addition, the dress code of female employees should be employee friendly as it will provide a greater impact to enhance comfortability in improving job performance and productivity (Rathnayake & Jayasinghe, July 2023). Female participation to the decision making is beneficial at the individual, community, and national levels. Thus, these policy suggestions will be a benchmark to ensure equal and diverse participation at the executive level.

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AI and Man: A Philosophical Analysis on Two Noninterchangeable Ontologies.

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Introduction

Artificial intelligence (AI) can be defined, in simple terms, as processes by machines that aim to simulate human intelligence, for example, natural language processing (NLP), speech recognition, machine vision, deep learning, etc (Somani, Horsch & Prasad, 2023). Hence, AI is all about developing new systems with human intellectual capabilities such as reasoning, meaning making, conceptualizing, theorizing, and learning from the past. The AI systems are basically oriented on training machines to perceive their immediate environments and respond to such conditions to achieve defined goals (Brachman & Levesque, 2023). In the case of understanding patterns and mimicking human beings, AI needs to analyze a huge sum of information.

“Key — applications (of AI) include speech recognition, language translation, visual perception, learning, reasoning, inference, strategizing, planning, decision making, and intuition. There are several underlying disciplines encompassed within the field of AI, including big data, data mining, rules-based (expert) systems,

neural networks, fuzzy logic, machine learning (ML), deep learning (DL), generative adversarial networks, cognitive computing, natural language processing (NLP), robotics, and the recognition of speech, images, and video.” (Talwar, 2017, p4).

In this paper, the major research problem to be investigated will be ontological conditions of human mind and AI algorithms in the case of thinking. Ontologically, human intelligence is not limited to ingesting large amounts of labeled data, analyzing them for correlations and patterns, and using these patterns to make predictions about future states, like AI bots. Accordingly, human intelligence is not a statistical engine for pattern matching or gorging on hundreds of terabytes of data, as Norm Chomsky highlights (Chomsky, 2023).

If AI, simulating the human brain, can think like human beings and imitate the thinking process, the key philosophical question to be addressed is what is meant by “thinking”? Consciousness or understanding, intentionality, and self-awareness are some concerns that arise here and they will have to

be dealt with existential and phenomenological philosophy, at the outset. Though AI continues to advance and makes many advanced pieces of technology akin to human thinking. Human consciousness is far different from AI, not having a plan, in its very nature can be understood as an activity that is very intentional and phenomenologically reduced. Human ontology is created with its *care* on the world in contrast to the machine, consciousness transcends itself. Intentional consciousness of human beings is correlated to the surroundings in which they live or their world; machines will not be able to grasp the practical connotations of wilful interests. There is no central ~~one~~ understanding for human beings, but machines presuppose some rules.

Literature review

In essence, the question of whether a machine can think relies on the definition given on the manner in which we define "thinking" and the very philosophical problem has a long history in different traditions. The most ostensible manifestation of the philosophical problem of thinking was witnessed with the philosophizing project of René Descartes, the French philosopher, scientist, and mathematician, who came up with the idea of *cogito, ergo sum* (I think, therefore I am) (Watson, 2002). This was Descartes's "first principle" as philosophy is a matter of axioms; the philosophers throughout the history had used different sets of axioms to construct philosophical arguments of realities they encountered. Hence, axioms stood as self-evident facets of reason. Descartes' problem was whether axioms used by previous philosophers are self-evident.

"The Meditations on First Philosophy are as original in philosophical form as in content. 'First philosophy' would have been recognized by Descartes's readers as synonymous With 'metaphysics', the study of being in general, rather than particular kinds of being: but although he speaks of the work — as his 'metaphysics', he prefers the title 'Meditations on First Philosophy', because the book deals 'not specifically with God and the soul, but in general with all the first things we can know by philosophizing'." (Descartes, 2008, p 89)

With this argument Descartes developed his skepticism and raised the question of popular dreaming or having many Schizophrenic worlds. Doubting everything in the world led to postulating his first axiom on 'thinking' (Katz, 1986). Then he formulated the correlation between existence and thought. This thinking is all about reflective thinking on our existence. Thinking is a conscious activity and through thinking human beings will be able to ensure their existence in one form or another.

For Descartes, the subject, or cogito, is a thinking thing that is not extended. Only the object is an extended thing and it does not possess thinking capacities. Thinking is a mental process that leads to forming thoughts, making decisions, solving problems, and engaging in reasoning, connected with some cognitive activities, like perception, memory, language processing, and problem-solving has a closer connection to consciousness, which refers to the state of being aware of and able to think about one's own thoughts, feelings,

sensations, and surroundings. Somebody's consciousness derives from the subjective experience of awareness and the capacity for self-reflection. When it comes to the sensation of being a human being, it is all about self-awareness and intentionality (Smith & McIntyre, 2012). A human being's ontological essence is created through the engagement with the world or society and not predetermined.

“This already—being—is first of all not merely a rigid gazing at a purely existing thing. Being-in-the-world is dazed as a preoccupation of the preoccupied world. In order for cognition to be possible as an observing determination of what is present, a deficiency of the preoccupying engagement with the world is required in advance. In the withholding of all making, handling and the like, worrying settles into the only remaining mode of being-in, into the only remaining dwelling with...”
(Heidegger, 1962, p. 86)

Statistical approaches to AI make some predictions on future events and would come with much more accurate results than the human initiation. But, the irreplaceable capacity of the human mind is hidden in intuition and it is more than logic and a greater set of neural networks. The evolutionary algorithms are still able to work on large amounts of data and identify patterns based on reasoning or logic. The human mind goes beyond mere reasoning or logical patterns. Old fashioned AI systems were basically focusing on symbol manipulation, and new approaches to AI are more concerned on intuition (Hunt, 2012). But the issue with the AI systems is as Roger Penrose understands “Intelligence cannot be present without understanding. No

computer has any awareness of what it does.”
Citation?

Turing's understanding of the machine's thinking capacity was a narrow one and he opined that if a machine can mimic a human being in an indistinguishable way like a human being that machine can think. AI systems can simulate human thinking rather than “thinking”. Human consciousness is a different thing than just a simulation. Human consciousness is integrated with the physical world and a meaningful world, for Heidegger, does not appear for a singular transcendental “I”; rather an entanglement where no dichotomies of subject/object are manifested. The human-matching intelligence of machines will have a severe problem with self-awareness, where human beings are characterized by their ability to question their own existence. This confrontation of the fundamental questions of being is defined by its temporality in contrast to rule-based ontology of a machine.

Significance of the Study

No philosophical investigation has been conducted on ontological difference between an AI system and human beings. Though Landgrebe & Smith (2022) had studied on reasoning aspects of artificial and human intelligence, no philosophical analysis has been done. Mitchell (2019) has studied on mimicking of human learning, perception, language, creativity and common sense by machines, but ontology of two entities had not been investigated. Though Sonik & Colarossi (2020) address the problem of fundamental being of humans and computers, their study is not very specific of grand ontological question of what is the fundamental substance. In the literature survey it was identified that there is a huge research gap pertaining to comprehension of ontology of artificial intelligence and

studying the same will help to advancement of Artificial Intelligence discipline itself.

Methodology

Hermeneutics has been used as the methodology of this study. Interpretation of existing literature to come up with a new theory and understanding of ontologies of humans and machines has been done. Ages old philosophical ideas pertaining to “thinking” have been tested with logic behind AI systems, questioning fundamental aspects of existence. Uncovering the underlying structures of the ontology of humans and machines were investigated as an interpretative endeavor.

Discussion

Though some would argue that machines can exhibit certain qualities such as consciousness, intentionality, and self-awareness that are traditionally attached with human ontology, for Derrida (1989), human ontology is origin-heterogeneous. This marks the difference between a trained machine and a human being. A computer works in a rationality, throughout its history, aligning with a set of rules or procedures for transmitting data between different electronic devices. This preexisting agreement over the computations can be disarrayed at a certain point in time in advancement of artificial intelligence; in a sense, an AI system would garner its own so-called “free will” with its own irrationality. But the origin of an AI algorithm is still a planned and non-origin-heterogeneous entity.

If AI is going to replace the human brain, all the faculties of the human mind need to be replicated by AI machines including consciousness, moods, mental states, etc. Eventually the grand philosophical question

of whether a machine will or can have a mind arises with the latest developments of AI technologies (Avramides, 2000). Qualia, the subjective and conscious experience of human beings, has not yet been replicated by the AI systems so far. Qualitative characteristics of sensation felt by the human brain stand as a non-computable feature of human life still no AI system has reached this realm; the argument in this paper is focused on the speculative possibility of qualia by AI algorithms (Stubenberg, 1998).

This mystery of consciousness is ontologically nonalgorithmic and being of AI bot is not in the mode of “uncovering”. The ‘organism’ of the human mind is far different from an AI ‘machine’ as Nagel would highlight that an organism has conscious experience that is unique and makes an organism an organism. The materialist idea of consciousness arises from the material brain itself and brain activity is the only cause behind the “mystery of consciousness” (Wilberg, 2004). Human organisms are involved with and caring for the immediate world. The phenomenal experience of human beings derives from a complex organism, the problem will be whether that can be replaced by an experiencing machine. Pre-theoretical and intuitive human mind is the most interesting part and the mind is not a plan (James, 2011). Human mind and its essence creates itself. Human mind’s essence is realized in terms of the possibilities being with the world. Human mind is inherently and essentially social and bound to the world in which the human being is posited.

Ontology of human mind is far different from the logic driven AI as Yudkowsky (2008) noted building a jet airliner by copying a living bird would never be similar to the organism of a bird. Human intelligence is majorly supported by intuitive judgements rather than a logical manipulation of symbols. Human mind’s such ability would never be grasped by a

rules-based AI system. Unconscious reasoning and learning are part and parcel of the human mind. To grasp the human mind as a neural network would be mere mirage and human "Da-sein" is always pre-ontological (Heidegger, 1996). This prescientific nature of the human mind is totally different from an AI system and one cannot be replaced by the other as one has a planner and the other has no planner (Dreyfus, 1972). Human mind's origin is always conceived as self-identical and has no set of rules or logic behind it. As Derrida pinpoints, the origin of human consciousness is immediately divided (Derrida, 2023). Human mind is an accident; AI algorithms are rules based. Hence, the human mind's understanding precedes abstract ways of knowing. Ontologically, the human mind is not oriented on logic or theory; but the AI is. So, AI can be understood, in contrast to the human mind, as a unitary phenomenon rather than a contingent one (Mitchell, 2019). Human mind's origin heterogeneous quality is immediate and nothing is ever given as such in certainty. Therefore, an AI bot will never replace a human being as a human being's reality is whatever is given is given as other than itself. Human reality is not comprehensible and scientific; rather intuition oriented and it is always in the past or yet to come.

AI's essence precedes logic and human being's essence precedes illogical, unfathomable irrationality in origin-heterogeneous.

Conclusion

Autonomy of AI systems is questionable with the non-origin-heterogeneous ontology of it and they act as automata with a plan. Contingencies have been removed or eliminated from the logical progression of rule-based AI systems and for the human mind's ontology there is no rule as such. In this contingency there is no truth or no

perception or no intuition as such. Hence artificial intuition will not replace the human's as the human consciousness is always late for the origin. Human experience is "out of joint" in the Derridean sense. Such an anachronism would be possible with the human being not with the machines.

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Impact of Financial Literacy on Individuals' Financial Behaviour of Employees in IT Industry in Sri Lanka

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Abstract— This study investigates the influence of financial literacy on the financial behavior of IT industry employees in Sri Lanka. The main objective is to determine the overall impact of financial literacy on financial behaviors, with a focus on savings, credit, and budgeting. Utilizing a positivist paradigm and hypothetical deductive methodology, data were collected from 384 respondents through a structured questionnaire. The conceptual framework focuses on three primary aspects of financial literacy: savings, credit, and budgeting. The findings reveal significant positive correlations between financial literacy and financial behaviors. Specifically, financial literacy on savings (4.031 ± 0.419), credit (4.025 ± 0.496), and budgeting (4.010 ± 0.448) were all positively correlated with financial behaviors (4.026 ± 0.451). Regression analysis indicated that financial literacy accounts for 61.7% of the variation in financial behaviors ($R^2 = 0.617$). These results underscore the necessity of financial literacy for effective financial decision-making and its role in promoting financial stability and well-being among IT professionals. These insights are crucial for designing targeted financial education programs to enhance financial literacy and encourage positive financial habits within the IT sector.

Keywords-Credit, Decision Making, Financial Literacy, IT Industry, Savings Behaviour,

I. INTRODUCTION

Financial skills are crucial for individuals to make sound financial decisions in a volatile economic environment (Fatoki, 2014). The ability to manage finances effectively stems from possessing solid financial knowledge and skills, which leads to stability and well-being in personal and family lives (Pham & Le, 2023). The necessity for good financial management skills is growing due to the increasing complexity of financial products and the heightened awareness of the need to save for retirement plans (Grohmann, 2018). Thus, the level of knowledge a person has about financial affairs is beneficial for making day-to-day financial decisions. Furthermore, financial skills are essential for building individual well-being and contributing to economic growth (Tharanga & Gamage, 2021). Additionally, strong financial skills contribute to economic growth and stability (Pham & Le, 2023). This is especially important for the growing middle class in emerging economies in Asia (Grohmann, 2018). Therefore, financial literacy is crucial for individuals to make

effective financial decisions and is significant for the country's economic growth (Tharanga & Gamage, 2021).

Financial literacy refers to the ability to make proper decisions and effectively manage money and finances (Edirisinghe et al., 2017). Dwiastanti (2015) clarified that financial literacy comprises the skills and abilities to use existing resources to achieve desired goals. According to Khawar & Sarwar (2021), financial literacy involves the accumulation of knowledge, skills, and strategies acquired throughout life, extending beyond understanding financial concepts to include practical application, logical thinking, positive attitudes, and motivation. The ability to manage personal finances has become increasingly important (Hasibuan et al., 2017). Reswari et al. (2018) noted that people with low financial literacy tend to struggle with managing their finances. With the shift in financial responsibility, scholars have focused more on the relationship between financial literacy and individual financial behaviour (Scheresberg, 2013).

Financial behaviour includes how people manage, handle, and apply available financial resources. Proactive financial behaviours, such as budgeting, saving, and expense awareness, lead to better financial outcomes (Dwiastanti, 2015). Effective financial behaviour involves actions like maintaining accurate financial records, tracking cash flow, establishing savings strategies, budgeting, paying bills promptly, monitoring credit card usage, and handling debts responsibly (Zaimah et al., 2013). Literature shows that individuals with good financial knowledge and skills excel in budgeting, saving, managing expenses, and handling debts (Andarsari & Ningtyas, 2019). Middle-aged individuals who attended personal financial management courses in high school tend to save more of their income (Mandell & Klein, 2009). Empirical research has also shown that financial literacy leads to positive financial behaviour and outcomes.

Research Gap

Previous research on financial literacy and financial habits has produced conflicting results (Xu et al., 2022; Mireku et al., 2023; Purwidiyanti & Tubastuvi, 2019). While concepts such as spending, saving, credit, financial management, and budgeting have been explored, financial literacy lacks a universally accepted definition (Jemal, 2019; Yakob et al., 2021). This ambiguity complicates the precise examination of the relationship between financial literacy and

financial behavior. Moreover, there is a scarcity of data on how financial literacy influences financial decisions in developing nations (Tharanga & Gamage, 2021). Specifically, few studies have investigated this topic within the context of Sri Lanka, and even fewer have focused on the IT industry. This study aims to address these gaps by examining the impact of financial literacy on the financial behaviors of IT industry workers in Sri Lanka.

Research Problem

Financial literacy significantly influences financial decisions globally (Andarsari & Ningtyas, 2019). Research on its impact on spending behaviour shows mixed results; while financial experience is crucial (Xu et al., 2022; Mireku et al., 2023; Khawar & Sarwar, 2021), some studies find no strong link between financial knowledge and behaviour (Susdiani, 2017; Purwidiyanti & Tubastuvi, 2019). Developing countries, including Sri Lanka, often lack focus on financial knowledge, leading to poor financial behaviours and economic challenges (Xu et al., 2022; Andarsari & Ningtyas, 2019). Limited research in Sri Lanka calls for deeper exploration to provide valuable insights (Tharanga & Gamage, 2021). Despite rising opportunities and salaries in the IT sector, financial literacy among employees remains limited (Odek, 2015). This study aims to understand how IT industry employees in Sri Lanka use financial literacy to manage their financial behaviours.

Significance of the Study

This study is significant both academically and practically. Academically, it contributes to understanding the influence of financial literacy on the financial behaviours of IT industry employees in Sri Lanka, providing valuable insights for policymakers and educators. The findings can help design targeted financial education programs to enhance financial literacy and encourage positive financial habits. Practically, the research offers valuable knowledge for managers, employers, and employees, aiding in the effective management of financial behaviours. Organizations can tailor training programs to improve employees' financial decision-making and well-being, while employees can use this knowledge to make better financial decisions and achieve financial stability.

Research Objective

The study emphasizes the need to investigate the influence of financial literacy on the financial behaviours of employees in the IT industry in Sri Lanka, in order to fulfill the aim the following objectives of the research were identified.

1. Assess the influence of financial literacy regarding savings on financial behaviours.
2. Assess the influence of financial literacy about credit on financial behaviours.
3. Assess the influence of financial literacy about budgeting on financial behaviours.
4. Assess the influence of overall financial literacy on financial behaviours.

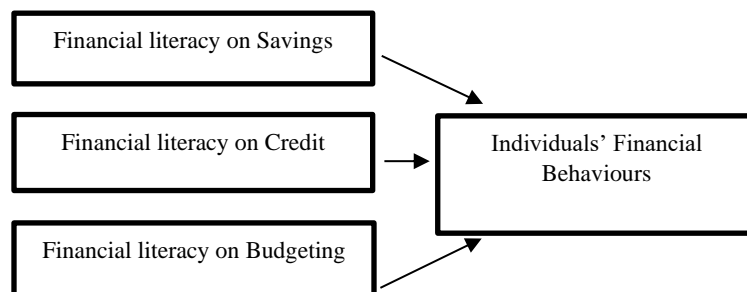
Limitations of the Study

The primary constraints of this study are linked to the methodology. The cross-sectional research design limits the study to a single point in time, restricting the examination of changes in financial behaviour. Using questionnaires to gather data may introduce response biases and fail to capture the complete range of financial behaviours. The relatively selected sample of 385 IT personnel may also limit the generalizability of the findings.

II. METHODOLOGY

Conceptual Framework

Based on earlier research, different aspects of financial knowledge were identified. By connecting various factors that affect financial behaviours, a model can be created to understand how individuals handle their finances.



Source: Authors

Hypotheses

- H1: There is a positive influence of financial literacy regarding savings on the financial behaviours of employees in the IT industry in Sri Lanka.
- H2: There is a positive influence of financial literacy about credit on the financial behaviours of employees in the IT industry in Sri Lanka.
- H3: There is a positive influence of financial literacy about budgeting on the financial behaviours of employees in the IT industry in Sri Lanka.
- H4: There is a positive influence of financial literacy on the financial behaviours of employees in the IT industry in Sri Lanka.

The research design, guided by Saunders et al.'s (2019) research onion framework, combines various components systematically to achieve data collection, measurement, and analysis. Adopting a positivist philosophy, the study quantifies the correlation between financial literacy and financial decision-making among IT professionals in Sri Lanka through a hypothetical deductive methodology. Using deductive reasoning, hypotheses are formulated and tested within a structured research design. The study

Age	Frequency	Percent
Less than 25	9	2.30%
26 - 35	166	43.20%
36 - 45	204	53.10%
Above 45 years	5	1.30%
Total	384	100.00%

adopts a quantitative approach, collecting data via a structured questionnaire and analyzing it quantitatively. It is cross-sectional, capturing data at a specific point in time from a target population of IT employees in Sri Lanka. With a sample size of 385, determined at a 95% confidence level and a 0.05 significance level, convenience sampling is used despite potential biases and limitations in generalizability.

Data Collection Method

The research employed primary data sources collected through structured questionnaires distributed to employees in the IT industry in Sri Lanka. The questionnaire consisted of closed-structured questions. It was divided into three

sections: A, B, and C, with questions presented in English. Section A contained demographic information, Section B encompassed factors related to financial literacy, and Section C delved into the financial behaviours of the individuals in the sample. The distribution was carried out online via Google Forms.

III. DATA ANALYSIS AND FINDINGS

Response Rate : The study targeted IT sector workers in Sri Lanka, distributing 385 surveys and receiving 384 fully completed forms, achieving an impressive 99.75% response rate. This high response rate, as highlighted by Mugenda and Mugenda (2003), exceeds the threshold for excellence (70% or more), indicating a robust representation of the study population.

Sample Characteristics

Gender of Respondents: The sample comprised 208 males (54.20%) and 176 females (45.80%), indicating a higher number of male employees in the IT sector.

Table 1. Gender of the respondents

Gender	Frequency	Percent
Male	208	54.20%
Female	176	45.80%
Total	384	100.00%

Table 2. Age of the respondents

Age of Respondents: Most respondents (53.10%) were aged 36-45 years, followed by 43.20% aged 26-35 years. Only 2.30% were under 25, and 1.30% were over 45, suggesting that the IT sector workforce is predominantly young.

Educational Qualification: The majority (68.80%) held a Bachelor's degree, followed by 17.20% with certificates or diplomas, 10.40% with Master's degrees, and 3.10% with GCE A/L qualifications. Only 0.50% had a Doctorate degree.

Table 3. Education Qualification

Variables	Cronbach's Alpha	No. of Items
Financial Literacy on Savings (SL)	0.888	04
Financial Literacy on Credit (CL)	0.914	04
Financial Literacy on Budgeting (BL)	0.906	04
Individuals' Financial behaviours (FB)	0.951	04

Working Experience: The majority of respondents (59.40%) had 2-5 years of experience, 27.90% had 5-10 years, and 12.20% had less than 2 years of

Variables	KMO	Sig. Value
Financial Literacy on Savings (SL)	0.792	0.000
Financial Literacy on Credit (CL)	0.791	0.000
Financial Literacy on Budgeting (BL)	0.788	0.000
Individuals' Financial behaviour (FB)	0.893	0.000

experience. Only 0.50% had more than 10 years.

Table 4. Working Experience

Work Experience	Frequency	Percent
Less than 2 Years	47	12.20%
2 – 5 Years	228	59.40%
5-10 Years	107	27.90%
Above 10 Years	2	0.50%
Total	384	100.00%

Education	Frequency	Percent
GCE. Advanced Level	12	3.10%
Certificates/ Diploma	66	17.20%
Bachelor's Degree	264	68.80%
Master's Degree	40	10.40%
Doctorate	2	0.50%
Total	384	100.00%

Current Working Industry : All respondents (100%) were employed in the IT industry.

Data Validity Test

Reliability Test: The Cronbach's Alpha test was used to assess reliability. All four variables exceeded the 0.7 threshold, indicating good internal consistency.

Table 5. Reliability Analysis

Validity Test: The KMO values were all above 0.5, and the significance values were less than 0.05, confirming the validity of the research.

Table 6. Validity Analysis

Descriptive Statistics: Descriptive statistics were used to analyze each variable. The mean scores indicated a positive perception of financial literacy and behaviours among respondents.

Table 7. Descriptive Statistics

	SL	CL	BL	FB
Mean	4.031	4.025	4.010	4.026
Median	4.000	4.000	4.000	4.000
Std. Deviation	0.419	0.496	0.448	0.451
Minimum	1.750	1.500	1.750	1.750
Maximum	4.750	5.000	4.750	4.880

	Value
R	0.79
R ²	0.617

Normality Test: The Skewness and Kurtosis values fell within acceptable ranges, indicating a normal distribution for most variables

Table 8. Normality Test

Multicollinearity: No multicollinearity issues were found, as all VIF values were below 10.

Table 9. Multicollinearity Test

Correlation Analysis: There were high positive correlations between financial literacy components and financial behaviours, all significant at the 0.01 level

Table 10. Correlation Analysis

	SL	CL	BL	FB
SL (P. Correlation)	1			
Sig. (2-tailed)				
CL (P. Correlation)	.721**	1		

Sig. (2-tailed)	0.000			
BL (P. Correlation)	.775**	.639**	1	
Sig. (2-tailed)	0.000	0.000		
FB (P. Correlation)	.740**	.687**	.688**	1
Sig. (2-tailed)	0.000	0.000	0.000	

Regression Analysis: Regression analysis indicated that financial literacy significantly impacts financial behaviour. The R-square value of 61.7% shows that financial literacy accounts for a significant portion of the variation in financial behaviours.

Table 11. Model Summary

	Skewness	Kurtosis
SL	-1.894	2.346
CL	-1.229	2.742
BL	-1.620	3.043
FB	Tolerance -1.425	VIF 2.788
SL	0.313	3.191
CL	0.464	2.153
BL	0.386	2.590

The ANOVA test confirmed the model's significance (p-value = 0.000). The coefficients indicated positive effects of financial literacy on financial behaviours

Table 12. Coefficient and ANOVA

	Coefficient	p-value
SL	0.387	0.000
CL	0.255	0.000
BL	0.232	0.000

IV. DISCUSSION AND CONCLUSION

The study aimed to investigate the impact of financial literacy on financial decisions among IT employees in Sri Lanka, using data from 384 respondents with a response rate of 99.74%. The high response rate indicates strong participant engagement, and the data collected were reliable and valid.

Key findings include:

1. **Savings Literacy:** Employees with higher savings literacy practiced better budgeting and financial responsibility, indicating that understanding savings concepts contributes to overall financial well-being.
2. **Credit Literacy:** Better credit management knowledge led to effective handling of credit, avoidance of excessive borrowing, and proper credit score management. Understanding credit-related issues helps manage borrowing and lending effectively.
3. **Budgeting Literacy:** A deep understanding of budgeting significantly impacted financial behaviours, enabling effective financial planning and resource allocation. Budget literacy is crucial for financial discipline and resilience, especially in the IT industry.
4. **Overall Financial Literacy:** Higher overall financial literacy strongly influenced positive financial behaviours, promoting financial stability through saving, debt management, and adherence to budgets.

The study supports the theory that financial literacy positively influences financial behaviours. It highlights the importance of tailored financial education programs for IT workers, empowering them to make informed financial decisions. This is crucial for their well-being and economic stability, ultimately benefiting the financial sector's stability.

V. RECOMMENDATIONS

The analysis demonstrates that personal financial management significantly influences the economic behaviours of IT industry employees. The study highlighted the impact of financial literacy on saving, credit management, and budgeting, underscoring the need for customized financial education programs, staff productivity projects, and integration of financial literacy into job training.

Key recommendations include:

1. **Customized Financial Education:** Develop tailored financial education programs and integrate them into job training to enhance financial competence and decision-making.
2. **Strategic Partnerships:** Establish partnerships with financial institutions and educational entities to provide necessary resources and expertise for ongoing financial literacy initiatives.
3. **Regular Evaluation:** Companies should regularly evaluate and monitor financial literacy programs to ensure their effectiveness and relevance.
4. **Data-Driven Insights:** Use data-driven insights and collaboration to continuously refine financial education programs to meet the evolving needs of IT sector employees.

These efforts will help employees navigate the complex financial world confidently, fostering a culture of financial responsibility and contributing to their overall professional success.

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ABBREVIATIONS AND SPECIFIC SYMBOLS

FL – Financial Literacy

SL – Financial Literacy on Savings (Saving Literacy)

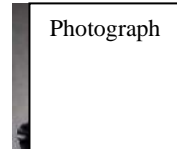
CL - Financial Literacy on Credit (Credit Literacy)

BL - Financial Literacy on Budgeting (Budgeting Literacy)

FB – Individuals' Financial Behaviours

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**Effect of social media usage on behavioral changes in adolescents
attending the District General Hospital Hambantota.**

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ABSTRACT

Abstract – Social media, an internet-based form of communication, has become an integral part of adolescents' lives, strongly influencing their behavior. While it offers both positive and negative impacts, excessive usage exposes adolescents to risks such as internet addiction, cyberbullying, body image concerns, and reduced engagement in healthy activities. The global number of social media users reached 3.484 billion in 2019, marking a 95% year-on-year increase. This study aimed to evaluate the impact of social media usage on behavioral changes among adolescents attending the DGH-Hambantota. A descriptive quantitative study was conducted at DGH-Hambantota from May to June 2024. Data were collected using self-administered questionnaires distributed to the parents of adolescent who are attending the wards and pediatric clinic with 181 respondents participating (n=181). Data analysis was performed using SPSS version 25. Results indicated 86.2% of responders (adolescents' parents or guardians) believe that there is a difference of the behaviour of their child due to the social media. You Tube was used by majority (47%) When considering the behavioral changes perceived by the parent /guardian the highest mean value of 26.55 reflected a tendency to drift

away from family. The second highest mean value of 14.20 showed a preference for social media over academic work and household chores. The third highest mean value of 10.88 indicated behavioral changes due to social media. The lowest mean value of 4 was associated with mobile phone ownership and imitation of social media icons. Overall, the study highlighted the significant impact of social media on adolescents' behavior and attitudes. In conclusion, the study found that many adolescents are addicted to social media, leading to behavioral changes that affect their daily lives and mental and physical health. The findings underscore the need for addressing social media addiction to improve adolescents' overall well-being.

Keywords: Social media addiction, adolescents, behavioral changes

Introduction:

The development of technology in social media opens a gateway approach for several firms like education, economical and other categories. Social media is the collection of tools and online spaces available to help individuals and business to accelerate their information and Communication needs (Axel, 2009). The immeasurable growth of social media applications has provided more opportunities for people of all ages to interact, share, communicate, and comment, beyond past download or upload. The literature shows the adolescents comparatively use this technology more widely than people in other age groups (Weerasundera et al., 2014). Social media is a big part of many adolescents' lives. There are YouTube Facebook, Instagram or Snap chat, twitter etc. Adolescents use social media for entertainment and self-expression. Adolescence is the transitional phase of growth and development between childhood and adulthood. The world Health Organization (WHO) defines an adolescent as any person between ages of 10 and 19. They usually live with Internet and inter connected with social media. Modern young generation is often addicted to social media for fulfilling their day today activities. Positive and negative aspects of behavioral changes may arise from this social media addiction. Social media leads to behavioral addiction and its leads to the Formation of health threatening behaviors which harms to physical and mental health of addicted individuals. Therefore, the current study assessed impact of social media usage on behavioral changes among adolescents attending Child Guided Clinic (CGC) in District General Hospital Hambantota (DGHH).

Methodology:

A quantitative, descriptive cross-sectional study was conducted in the pediatric wards and clinic of the District

General Hospital Hambantota, the only general hospital in the Hambantota District of Sri Lanka's Southern Province. The hospital has 1,000 beds, 41 wards, seven theatres, two intensive care units, 14 labor room beds, 22 accident and emergency beds, and clinic premises serving over 600 patients. The pediatric clinic, held every Thursday, sees an average of 1,000 patients monthly, while the two pediatric wards admit about 500 patients monthly. The target population was the parents of adolescent children (aged 10-16 years) attending the pediatric wards and clinic. Inclusion criteria included parents of adolescent children who gave consent, while exclusion criteria included parents with psychiatric disorders, illiterate parents, and adolescents unwilling to participate. Data collection involved a structured questionnaire with three parts: demographic data, social media usage, and behavioral changes due to social media. Pre-tested among 20 parents, the questionnaire ensured clarity and understandability. Ethical clearance was obtained from the Ethical Review Committee of KIU(KIU/ERC/024/037), and permission was received from the hospital director. Data were collected using printed copies of the questionnaire, administered in Sinhala, with a completion time of 20-30 minutes. Data analysis was conducted using SPSS version 25, employing descriptive statistics such as frequencies, percentages, medians, and percentiles. Confidentiality of personal details and voluntary participation was ensured. Data were securely stored with restricted access given only to the principal and co-investigators.

Result:

Out of the 181 participants 68% were answered by Adolescents' mother. 68.5% were parents with adolescents aged 10-13 years. 55.2% were females adolescents. Majority 49.1% had a monthly income higher than

Rs.50,000/=. 48.1% of the adolescents had only one sibling.

Number of siblings

None

One

Two

Three or more than three

Table 1- Socio demographic characteristics of the Participants

variables		Siblings age	Numbers (N=181)	Less than 10 years	Between 10-20 years	Above 20 years
Answered by	mother		123	68		
	father		27	14.9		
	guardian	According to the analysis, 87% of parents/guardians perceived that their child exhibited behavioral changes due to social media usage. These changes were categorized into four main areas: mobile phone ownership, drifting away from family, wasting time, and day-to-day behavioral changes due to social media addiction. Questions related to each subscale were asked, and responses were collected using a 5-point Likert scale. The scores received are shown in the Table 2.	124	17.1		
Age in year	early adolescence (10-13)		124	68.5		
	middle adolescence (14-17)		57	31.5		
Gender	male		100	44.8		
	female		81	55.2		
religion	Buddhist		173	95.6		
	Hindu		5	1.1		
	Islam		2	1.1		
	Christian		4	2.2		
	others	<i>Table 2 Behavioural changes due to social media</i>	0	0		
ethnicity	Sinhala		176	97.2		
	Tamil		2	1.1		
	Muslim		2	1.1		
	burger		1	0.6		
	others		0	0		
living area	urban area		102	56.4		
	rural area		79	43.6		
		Std. Deviation	2.27395			
		Range	11.00			
parent's occupation status		Minimum	22.00			
		Maximum	33.00			
	only father		47	26		
	only mother		10	5.5		
monthly income	both mother and father	Overall, "Drifting away behavior" has the highest mean and range, indicating it is the most prevalent and varied behavior observed. "Wasting time behavior" and "Addiction behavior" show moderate means and ranges, while "Ownership behavior" has the lowest mean and range, indicating it is the least prevalent behavior observed in the study. Chi-square test showed that these	124	68.5		
	Less than 15 000 rupees		18	6.1		
	Between 15 000 – 30 000 rupees		45	9.9		
	More than 30 000 – 45 000 rupees		45	24.9		
	Above 45 000 rupees		107	59.1		

behavioral changes were significantly associated with adolescents age (p=0.017).

Table 3 Association between socio – demographic characteristics and behavioural changes due to social media usage

Behavioral changes due social media(n=181)					
		moderate behavioral changes	high behavioral changes	Total	<i>p</i> Value
age in year	early adolescence(10- 13)	110	14	124	0.713
	middle adolescence(14- 17)	48	9	57	
gender	male	71	10	81	0.017*
	female	87	13	100	
religion	Buddhist	150	23	173	1.218
	Hindu	2	0	2	
	Islam	2	0	2	
	Christian	4	0	4	
ethnicity	Sinhala	153	23	176	0.749
	tail	2	0	2	
	Muslim	2	0	2	
	burger	1	0	1	
living area	urban area	88	14	102	0.218
	rural area	70	9	79	
parents occupation status	only father	43	4	47	3.446
	only mother	7	3	10	
	both mother and father	108	16	124	
monthly income	less than 15000rupees	10	1	11	3.332
	between 15000- 30000 rupees	17	1	18	
	more than 30000- 45000 rupees	36	9	45	
	above 45000 rupees	95	12	107	
number of siblings	None	22	6	28	7.485
	One	73	14	87	
	Two	39	3	42	
	Three or more than three	24	0	24	

Conclusion

This study underscores the significant influence of social media on the behavior and attitudes of adolescents attending DGH-Hambantota. The findings revealed that a substantial majority of parents observed noticeable behavioral changes in their children attributable to social media usage. Key areas of concern included drifting away from family interactions, prioritizing social media over academic and household responsibilities, and adopting behaviors and attitudes influenced by online trends. The high prevalence of social media addiction among adolescents highlights a critical issue that impacts their daily lives and overall mental and physical health. Hence it is recommended that parents should be educated on the importance of monitoring their children's social media usage, Schools should incorporate educational programs that focus on digital literacy and the responsible use of social media. Further establishing counseling and support services within schools and community healthcare settings can help adolescents and their families address issues related to social media addiction. Encouraging adolescents to engage in physical activities, hobbies, and face-to-face social interactions can help reduce the time spent on social media. Moreover, additional research is needed to explore the long-term effects of social media usage on adolescents' mental and physical health. Future studies should also investigate the effectiveness of various interventions designed to mitigate the adverse effects of social media addiction.

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Assessing the Perceived Logistics and Spatial Feasibility of Establishing an Export Processing Zone in Trincomalee, Sri Lanka.

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Abstract—

This study assesses the feasibility of establishing an Export Processing Zone (EPZ) in Trincomalee, Sri Lanka, by evaluating the perceived logistics and spatial feasibility, based on insights from an expert panel. The research focuses on key factors such as transportation infrastructure and land suitability, using a structured framework. The expert panel's perceptions were critical in assessing the overall and component-wise viability of creating an EPZ in Trincomalee, with their evaluations informing the calculation of the Perceived Logistics and Spatial Feasibility Index (PLSFI). Trincomalee demonstrated strong potential, achieving an PLSFI score of 0.67, closely aligning with the established Katunayake EPZ's score of 0.68. The expert panel identified strengths in Trincomalee's road infrastructure, effective rail system, port services, and a well-structured land use plan, with a focus on sustainability. However, challenges such as moderate transport growth were noted. The study concludes that, based on the expert panel's perceptions, Trincomalee has significant potential to become a competitive EPZ, contributing to Sri Lanka's economic growth. It is strongly recommended that policymakers prioritize the development of the Trincomalee EPZ, with a focus on enhancing transportation networks and attracting strategic investments to capitalize on the region's logistical advantages.

Keywords: *Export Processing Zone, Perceived Logistics and spatial Feasibility Index, Trincomalee*

I. INTRODUCTION

The potential of Trincomalee as an Export Processing Zone (EPZ) is essential to the economic growth of Sri Lanka. Although Trincomalee has been recognized as a viable site, its logistical and spatial feasibility have not yet been thoroughly examined. Any plans for future development will be hampered in the absence of this analysis. Furthermore, Trincomalee will be a lost opportunity for the nation if its resources are not developed. Therefore, it's critical to evaluate how interested parties view Trincomalee's logistical and spatial viability as an EPZ. By assessing the necessity for this opportunity, our research aims to close this gap

Our research aims to investigate the perceived logistics and spatial feasibility of establishing an Export Processing Zone (EPZ) in Trincomalee, Sri Lanka. Trincomalee's favorable location and abundant natural resources present opportunities for economic expansion and industry development.

The significance of this research lies in ensuring informed decision-making and

promoting sustainable economic development by evaluating the perceived logistics and spatial feasibility of implementing an Export Processing Zone (EPZ) in Trincomalee, Sri Lanka. This evaluation focuses on key factors such as land suitability and transportation infrastructure capabilities, which are critical for determining the readiness of the region for such a development. By assessing these elements, the study provides substantial insights into the strategic positioning of Trincomalee as a potential EPZ site. The findings highlight its logistical advantages, including its well-structured transportation networks, while also identifying areas that may

require improvements. These insights offer a comprehensive understanding of the region's ability to support an EPZ and its potential contribution to economic growth.

II. LITERATURE REVIEW

EPZ promote growth, innovation, and wealth and are essential to a country's economic progress. They are dynamic ecosystems that bring together organizations, technology, and people resources rather than merely being factories.

<i>Sub title</i>	<i>Authors</i>	<i>Statements</i>	<i>Remark</i>
<i>Road Infrastructure</i>	<i>Song et al. (2021)</i>	<i>Better road infrastructure conditions facilitate industrial growth and economic advancement</i>	<i>This model aims to enhance passenger and freight transit, fostering socioeconomic growth and increasing accessibility to Export Processing Zones.</i>
<i>Railway infrastructure</i>	<i>Nathanail (2014)</i>	<i>Framework for monitoring, maintaining and upgrading railway infrastructure to maximise efficiency has been presented.</i>	<i>The study highlights regional performance inequalities in Greece's railway network and the need for coordinated renovations.</i> <i>Its goal is to improve network efficiency, increase accessibility to Export Processing Zones (EPZs), and promote industrial development.</i>
<i>Port Parameters</i>	<i>Munim and Schramm (2018)</i>	<i>The complex relationship between port infrastructure quality, logistics performance, maritime trade, and economic growth in 91 countries with seaport infrastructure have been investigated.</i>	<i>The study highlights that improving port infrastructure will lead to better logistics efficiency, which will boost economic growth.</i>
<i>Airport Parameters</i>	<i>Gosling (1988) Mumayiz (1991)</i>	<i>Stress the value of standardized assessment techniques for the quality and service levels of airport patrons, especially in nations like Brazil without national-scale reporting system</i>	<i>Researchers developed quantified LOS measurements for airports using psychological scaling theory and multi-attribute analysis to enhance passenger experiences, operational effectiveness, and to promote economic growth in Export Processing Zones.</i>

<i>Spatial analysis</i>	<i>Michael (1997)</i>	<i>Covers ecological and statistical fundamentals, evolving methods, and emerging techniques like spatial graph theory, scan statistics, and Hierarchical Bayesian analysis in spatial analysis for eco - rical research.</i>	<i>Spatial analysis benefits Export Processing Zones (EPZs) through better site selection, more efficient resource allocation, and improved environmental management, contributing to sustainable and effective development.</i>
<i>Traffic Analysis</i>	<i>Mauche (2018)</i>	<i>Evaluates the effectiveness of transportation infrastructure projects using traffic analysis techniques like road safety analysis, flow characteristics, volume measures, and delays to increase traffic safety.</i>	<i>Traffic analysis benefits Export Processing Zones (EPZs) by optimizing transportation infrastructure, reducing traffic, expediting travel, and improving road safety, contributing to the safe and effective movement of people and products.</i>
<i>Utility demand assessment</i>	<i>Nikolaou (2011)</i>	<i>Utility demand assessment is essential for accurately anticipating energy demand based on construction and environmental conditions for ExportProcessing Zones (FPZs).</i>	<i>Real-time monitoring systems and historical data analysis maximise efficiency, lowering energy costs, promoting environmental sustainability, and raising overall operational efficiency within EPZs, increasing their appeal to stakeholders and investors.</i>

Table 1: Export Processing Zones (EPZs) Feasibility Factors: A Review of Relevant Studies

II. METHODOLOGY

A. Levels and Measurements of EPZ Components

Components of EPZ were identified. They were transportation infrastructure and land suitability. After that, elements for each component were identified through literature review. After that, for each element, levels or measurements of the elements were developed. The table 2 below displays the levels and the measurements of the elements.

B. Questioner design

The components of EPZ elements, levels or measurement of elements for each component are mentioned in Table 2. These were included in a questionnaire.

This questionnaire was shared among an expert panel. The expert panel was requested to state their perception on the existing logistics and spatial infrastructure in Trincomalee for setting up an EPZ. The expert panel was requested to state their perception based on the levels specified in the questionnaire as shown in Table 02. Finally, open-ended questions were provided to collect respondents' views on important indicators not mentioned in the proposed list above.

C. Expert Panel Evaluation process

An expert panel was appointed, comprising the Trincomalee Assistant Harbor Master, an entrepreneur from Trincomalee, an undergraduate student from the commerce Faculty of Commerce and Management of the Eastern

University, Sri Lanka, an aircraft maintenance engineer employed at Bandaranayake International Airport, and the procurement manager Abans Logistics Pvt Ltd, a private logistics company. Subsequently, an online meeting was arranged via Zoom, during which the panel members were presented with two scenarios: one concerning the proposed Trincomalee EPZ and the other regarding existing Katunayake EPZ. Following the presentation, a questionnaire was provided, and the panel members rated the questions between 1 to 3. Each panel member rated for both the Katunayake and Trincomalee scenarios. Table 3 outlines the scores rated for both proposed Trincomalee EPZ and the existing Katunayake EPZ. Finally, based on the ratings provided, the index value, known as the Perceived Logistics and Spatial Feasibility Index (PLSFI), was determined for the export processing zone as shown in Table 4.

D. Measurement of Total points/Total index value

In the panel discussion, after the members completed the questionnaire, the responses were analyzed by aggregating the scores assigned to each question. These individual scores were then summed to generate a **Cumulative Feasibility Score (CFS)** for each assessed component. This cumulative score provided a comprehensive measure of the perceived feasibility, with the final results reflected in Table 3. This approach allowed for a systematic evaluation of each factor, ensuring that the overall feasibility assessment was based on a balanced and detailed consideration of expert opinions.

E. Maximum Feasibility Score (MFS)

Another score, referred to as the Maximum Feasibility Score (MFS), was calculated by aggregating the highest

possible score for each question in the questionnaire. This score represents the theoretical maximum, assuming all components were rated at their highest levels.

F. *Measurement of PLSFI*

The Perceived Logistics and Spatial Feasibility Index (PLSFI) was calculated by dividing the Cumulative Feasibility Score (CFS) by the Maximum Feasibility Score (MFS). This calculation was performed for both Trincomalee and Katunayake to compare their feasibility levels.

<i>Component</i>	<i>Elements</i>	<i>Levels/Measurements</i>	<i>Index Value</i>
1. Transportation Infrastructure	1.1 Road infrastructure	a. Good: Well maintained roads, no congestion, adequate lighting, signage, and safety measures.	3
		b. Moderate: Manageable obstacles such as moderate traffic flow and sporadic congestion, occasional maintenance required.	2
		c. Poor: Poorly maintained surfaces, potholes, inadequate signage, frequent traffic congestion.	1
	1.2 Railway Infrastructure	a. High Suitability: Minimally worn tracks, well-maintained, effective signaling systems, extensive and well-connected network, adequate capacity, and high safety standards.	3
		b. Moderate Suitability: Some wear, occasional outages, reasonable connectivity, moderate capacity, and acceptable safety standards.	2
		c. Low Suitability: Significant damage, frequent outages, limited connectivity, inadequate capacity, and poor safety standards.	1
	1.3 Port Parameter	a. Highly Significant: State-of-the-art security, efficient cargo handling, advanced technology.	3
		b. Moderately Significant: Standard facilities, moderate technology, room for improvement.	2
		c. Poorly Significant: Antiquated infrastructure, lack of technology, inadequate security measures.	1
		a. Outstanding:	3

	1.4 Airport Parameter	Modern infrastructure, impeccable services, excellent accessibility, state-of-the-art technology, ample capacity.	
		b. Average: Adequate for current demand, reasonable access, and some technological integration.	2
		c. Low: Antiquated or inadequate infrastructure, restricted services, inadequate access, outdated technology, inadequate capacity.	1
2. Land suitability	3.1 Spatial Analysis	a. Land Use Mapping: Classification of land for EPZ suitability.	
		• Industrial land	3
		• Agricultural land	2
		• Residential land	1
		b. Infrastructure Mapping: Documentation of transport networks, utilities, and other key facilities.	
		• Excellent	3
		• Adequate	2
		• Insufficient	1
		c. Facility Mapping: Locating and cataloging existing facilities for EPZ development. (Administrative buildings and amenities)	
		• Abundant	3
		• Moderate	2
		• Scarce	1
	3.2 Traffic Analysis	The current traffic flow	
		• Smooth	3
		• Moderate	2
		• Congested	1
	3.3 Utility Demand	Assessment Evaluation of gas, electricity, water capabilities to meet EPZ needs, future growth projections considered.	
		• Well-equipped	3
		• Adequate	2
		• Inadequate	1
	3.4 Environmental	Sustainability Assessment of environmental impact, sustainability of operational procedures, waste management, compliance with regulations.	
		• Strong	3
		• Average	2
		• Weak	1

Table 2: levels and the measurements of the elements.

Components	Elements/Parameters	Characteristics	Maximum Possible points (MPP)	Trincomalee	Katunayake
(1) Transportation and Infrastructure	Road Infrastructure	Road Condition	3	2	3
		Signage and Lighting	3	2	3
		Traffic Congestion	3	2	1
		Infrastructure Suitability	3	2	3
	Railway Infrastructure	Track Condition	3	3	2
		Network Connectivity	3	1	1
		Capacity Assessment	3	1	1
		Safety Standards	3	2	2
	Port Infrastructure	Automation Level	3	1	2
		Cargo Tracking	3	1	2
		Turnaround Time	3	2	2
		Customs Clearance	3	2	2
		Security Measures	3	2	2
		Surveillance Effectiveness	3	1	3
	Airport Infrastructure	Infrastructure Rating	3	2	2
		Service Efficiency	3	2	3
		Land Connectivity	3	2	3
		Technology Implementation	3	2	2
		Capacity Adequacy	3	2	2
(2) Land suitability	Spatial analysis	Land Use	3	2	1
		Transportation Infrastructure	3	2	3
		Administrative Buildings	3	2	3
		EPZ Suitability	3	2	3
	Infrastructure capacity	Traffic Flow	3	3	1
		Traffic Bottlenecks	3	3	1
		Utility Capacity	3	2	2
		Utility Demand	3	1	1
		Environmental Practices	3	2	2
		Environmental Priorities	3	3	1
		Traffic Infrastructure	3	2	1
		Utility Infrastructure	3	3	3
			93	61	63

Table 3: Measurement of Total index value

	Index (PLSFI)
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These Colour-coded words are used to represent the characteristics and values of tables 3 and 4.	Strength
	Limitation
	Similarity
	TP (Total Points)
	MPP (Maximum Possible Points)

IV. DISCUSSION

The results of the Perceived Logistics and Spatial Feasibility Index (PLSFI) calculations for Trincomalee and Katunayake highlight the comparative potential of these two locations for establishing an Export Processing Zone (EPZ). The PLSFI for Trincomalee was calculated to be 0.66, and for Katunayake, it was 0.68. This small difference indicates that both locations show strong potential for EPZ development, with Katunayake having a slightly higher perceived logistics and spatial feasibility. However, both regions are closely matched, suggesting that each offers viable opportunities for investment and development in the logistics sector.

	Trincomalee	Katunayake
CFS	61	63
MFS	93	93
PLSFI = CFS/MFS	0.6559	0.6774
PLSFI approximated	0.66	0.68

Table 4: Overall Logistics Assessment

A. Strength of Trincomalee

The proposed Export Processing Zone (EPZ) at Trincomalee demonstrates strong potential based on its perceived logistics and spatial feasibility. The panel of experts provided a score of 2 out of 3 for road infrastructure, reflecting moderate conditions with

manageable congestion and the need for occasional maintenance. This score suggests that while the road network is functional, there is room for improvement to enhance its long-term feasibility for supporting an EPZ. Trincomalee's railway infrastructure received a higher score of 3, indicating that it is highly suitable due to well-maintained tracks, reliable signaling, and good connectivity, which are critical for the efficient movement of goods and improving regional mobility.

Port infrastructure was rated with a score of 2, indicating moderate logistics feasibility. While the port meets current standards, it would benefit from further modernization and increased efficiency to optimize import-export processes. Nonetheless, this rating shows that Trincomalee's port facilities offer a solid foundation for businesses looking to engage in international trade but may require additional investments to reach their full potential.

The spatial feasibility of Trincomalee also scored highly, with 3 points for land use suitability, underscoring the area's ability to support diverse industries. The traffic flow in Trincomalee was similarly rated at 3 points, indicating smooth operations and minimal congestion, which is essential for logistics efficiency. In comparison, Katunayake only received 1 point for traffic flow, indicating challenges in that area. Additionally, Trincomalee earned 3 points for environmental sustainability, highlighting its commitment to maintaining eco-friendly practices, which is a key factor in long-term spatial feasibility for industrial development.

B. Limitations of Trincomalee

The expert panel's assessment of both Trincomalee and Katunayake highlighted several infrastructural, technical, and service-related challenges that could impact the effectiveness of the proposed Export Processing Zones (EPZs). Trincomalee's transport system received a score of 2 out of 3, indicating moderate suitability. While the transport network supports basic logistical needs and shows potential for growth, it still lags behind the more developed infrastructure of Katunayake, which received slightly higher scores in key areas. Despite these limitations, Trincomalee's transport infrastructure can be enhanced through targeted investments, which would improve its overall feasibility as an EPZ. The assessment suggests that while Trincomalee holds promise, its transport network requires strategic upgrades to match the efficiency and capacity of more established zones like Katunayake.

C. Similarities between Trincomalee and Katunayake

The expert panel's assessment revealed several notable similarities between Katunayake and Trincomalee in terms of their logistics and spatial feasibility for establishing an Export Processing Zone (EPZ). Both regions received comparable scores across several key areas, including road infrastructure, where Katunayake scored 3 and Trincomalee scored 2, indicating that both have relatively well-maintained road networks with minor differences in congestion and maintenance needs. In terms of railway infrastructure, both locations scored similarly, with Katunayake receiving 2 points and Trincomalee 3 points, reflecting a shared potential in leveraging rail systems for connectivity. Additionally, in areas such as port services and customs clearance, both regions achieved similar scores, indicating that both possess adequate facilities for international trade.

In environmental sustainability, Trincomalee and Katunayake were closely matched, both

scoring high in terms of compliance with environmental norms and sustainable practices. These similarities, reflected in the Perceived Logistics and Spatial Feasibility Index (PLSFI) scores of 0.66 for Trincomalee and 0.68 for Katunayake, suggest that Trincomalee has comparable potential for EPZ development. The near-identical feasibility scores indicate that Trincomalee, like Katunayake, can successfully support an EPZ, with only minor infrastructural improvements needed to match the capabilities of the more established Katunayake EPZ. This similarity strengthens the feasibility of establishing an EPZ in Trincomalee, positioning it as a viable option for industrial and logistical expansion in Sri Lanka.

V. CONCLUSION

In conclusion, the assessment of Trincomalee's perceived logistics and spatial feasibility, as compared to Katunayake, demonstrates that Trincomalee is highly suitable for the establishment of an Export Processing Zone (EPZ). With a Perceived Logistics and Spatial Feasibility Index (PLSFI) of 0.66, nearly equivalent to Katunayake's 0.68, Trincomalee exhibits similar logistical strengths, particularly in road and rail infrastructure, environmental sustainability, and overall land suitability. These close scores suggest that despite minor areas for improvement, such as in port services, Trincomalee's logistical and spatial framework is robust enough to support an EPZ. The similarity in perceived feasibility highlights the potential for Trincomalee to develop into a key industrial hub, contributing significantly to Sri Lanka's economic growth.

VI. FUTURE WORK

Future research on the Export Processing Zone (EPZ) in Trincomalee could focus on the long-term viability and scalability of the region as a logistics and industrial hub. Key areas for exploration include the impact of infrastructure upgrades, such as the extension of the Meerigama-Kurunegala Expressway and

improvements to the port facilities, on the perceived logistics feasibility of Trincomalee and its ability to handle increased trade volumes, particularly for non-containerized cargo like cement and coal. Researchers could also assess the socio-economic benefits for local communities, including job creation and economic growth, while conducting comparative studies with other EPZs, such as Katunayake, to highlight competitive advantages. Additionally, the integration of sustainable practices, such as renewable energy and environmentally friendly logistics operations, could be evaluated to ensure alignment with global sustainability goals. Finally, strategic international collaborations, particularly with India and other regional partners, could be analyzed to enhance Trincomalee's logistical potential and position it as a key player in South Asia's trade network.

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Age of Social Media as a Marketing Tool for Long-Distance Bus Operations in Sri Lanka

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Abstract— This study explores the use of social media as a marketing tool among long-distance bus operators in Sri Lanka. Despite its potential to improve customer engagement and service delivery, the adoption of social media in the Sri Lankan public transport sector remains limited. The research identifies several barriers, including low awareness, perceived high costs, and a lack of technical expertise. By applying the Technology Acceptance Model (TAM) and the Diffusion of Innovations Theory, the study provides insights into the factors influencing social media adoption. Findings suggest that effective social media usage can enhance passenger satisfaction through real-time updates and accurate information. Recommendations include conducting awareness programs, providing training, implementing pilot projects, and collaborating with technology providers. The study compares Sri Lanka's social media practices with those of India, China, and Malaysia, highlighting successful strategies. Addressing the identified challenges can lead to better communication, increased passenger

trust, and a more efficient public transport system in Sri Lanka.

Keywords— Social Media Marketing , Public Transport, Passenger Satisfaction

I. INTRODUCTION

In Sri Lanka, the public transport system, particularly bus operators, has not fully embraced the potential of social media as a powerful tool for marketing and customer engagement. This study aims to focus on bus operators in Sri Lanka, both private and public, to assess their usage of social media and identify gaps and issues in its implementation. The study also seeks to provide recommendations for improving the use of social media in the public transport sector. The proper utilization of social media can significantly enhance communication with passengers by providing accurate and timely information regarding timetables, service updates, and costs. However, in Sri Lanka, the current use of social media by bus operators is marked by a lack of accuracy, dissemination of false information, and general unreliability. These deficiencies lead to passenger dissatisfaction and a reduction in trust towards public transport services.

The public transport system in Sri Lanka comprises both private and public bus operators who have not fully leveraged social media to improve their services. Effective social media usage could address several challenges faced by the public transport sector, such as inaccurate timetables, false information, and unreliability. The dissemination of timely and accurate information through social media can improve passenger satisfaction and foster a better relationship between operators and commuters. This study is essential as it investigates the extent to which social media is utilized by bus operators in Sri Lanka and explores the reasons behind the current state of social media usage. It also examines the potential benefits of adopting social media more extensively in the public transport sector.

The primary aim of this study is to determine the level of usage of social media as a marketing tool in the public transport system in Sri Lanka. By assessing the current state of social media usage among bus operators, this research seeks to identify the gaps in implementation and the issues that hinder effective use. Furthermore, the study aims to provide recommendations on how to improve social media marketing for bus operators in Sri Lanka. To achieve these aims, the study will address several key objectives to assess the current level of social media usage among bus operators, to identify the gaps in the implementation of social media marketing, to pinpoint the issues related to social media marketing, and to provide recommendations for improvement.

Addressing these objectives will offer valuable insights into how social media can be effectively used to enhance the public transport system in Sri Lanka. It is anticipated that the findings will highlight the potential benefits of social media marketing, such as improved communication with passengers, increased passenger satisfaction, and enhanced operational efficiency. By understanding the barriers to social media adoption and implementation, the study aims to provide practical solutions to overcome these challenges.

II. LITRETURE REVIEW

Social media has become an essential tool for communication and marketing across various sectors, including public transport (Ohara et al., 2024). It offers numerous benefits, such as improved customer satisfaction,

better service delivery, and enhanced operational efficiency. suggests that perceived usefulness and perceived ease of Studies have shown that public transport operators in developed countries utilize social media platforms to provide real-time updates, engage with passengers, and gather feedback (Kaplan & Haenlein, 2015). For instance, in cities like London and New York, transport authorities use social media to inform passengers about service disruptions, changes in schedules, and fare updates. This proactive communication helps build trust and reliability, encouraging more people to use public transport.

In contrast, the uptake of social media by public transport operators in developing countries, including Sri Lanka, remains limited (Jayasena et al,2024). Research indicates that many operators are reluctant to invest in social media due to perceived high costs and a lack of understanding of its benefits. In Sri Lanka, the public transport sector has been slow to adopt new technologies, with many operators still relying on traditional methods of communication (Perera & Munasinghe, 2017). This reluctance can be attributed to several factors, including limited financial resources, lack of technical expertise, and a general resistance to change. Furthermore, there is a significant gap in the literature regarding the specific challenges and opportunities associated with social media usage in the Sri Lankan public transport sector.

One of the significant challenges in implementing social media in the public transport sector is the lack of accurate and reliable information (Fadhel et al 2024). Passengers often complain about outdated or incorrect timetables, service disruptions not being communicated promptly, and fare information not being readily available. These issues contribute to a negative perception of the public transport system and reduce passenger confidence (Wijeratne & Perera, 2019). The dissemination of false information can lead to confusion and frustration among passengers, further exacerbating the problem. Effective use of social media could address these issues by providing real-time updates and accurate information, thereby improving the overall passenger experience.

The potential of social media to enhance customer engagement and satisfaction is well-documented. According to Mangold and Faulds (2016), social media can be a powerful tool for public transport operators to communicate with passengers, gather feedback, and build a sense of community. By actively engaging with passengers on social media platforms, operators can address their concerns, provide timely updates, and foster a positive relationship. This engagement can lead to increased passenger loyalty and higher levels of satisfaction. However, for this potential to be realized, operators need to overcome the challenges associated with social media adoption and implementation.

Several theories can be applied to understand the adoption and impact of social media marketing in the public transport sector. The Technology Acceptance Model (TAM)

use are key factors influencing the adoption of new technologies (Davis, 1989). In the context of social media marketing, this model can help explain why some public transport operators are more willing to adopt social media than others. Operators who perceive social media as a useful tool that is easy to use are more likely to incorporate it into their marketing strategies. Conversely, operators who view social media as complex and difficult to manage are less likely to adopt it.

The Diffusion of Innovations Theory by Rogers (2003) is another relevant framework. This theory explains how, why, and at what rate new ideas and technology spread. It can be used to understand the slow uptake of social media by public transport operators in Sri Lanka and identify strategies to accelerate this process. According to this theory, the adoption of new technologies follows a predictable pattern, with innovators and early adopters leading the way, followed by the majority and laggards. Understanding where public transport operators in Sri Lanka fall on this adoption curve can help in designing targeted interventions to promote the use of social media.

The Unified Theory of Acceptance and Use of Technology (UTAUT) also offers insights into the factors that influence technology adoption. According to this theory, performance expectancy, effort expectancy, social influence, and facilitating conditions are the key determinants of technology acceptance (Venkatesh et al., 2003). In the context of social media usage in the public transport sector, performance expectancy refers to the extent to which operators believe that social media will improve their marketing and communication efforts. Effort expectancy relates to the ease of using social media platforms, while social influence involves the impact of peers and stakeholders on the decision to adopt social media. Facilitating conditions refer to the availability of resources and support to implement social media effectively.

Despite the potential benefits of social media, the literature highlights several barriers to its adoption in the public transport sector. One of the main barriers is the perceived high cost of implementing and maintaining social media accounts. Many operators, especially those in developing countries, operate on tight budgets and may not have the financial resources to invest in social media. Additionally, there is a lack of technical expertise and knowledge among operators on how to effectively use social media for marketing and communication (Fernando & Perera, 2020). Training and capacity-building initiatives are needed to address these gaps and equip operators with the necessary skills to leverage social media effectively.

Another significant barrier is the lack of infrastructure and resources to manage social media accounts effectively. Many public transport operators do not have dedicated staff to handle social media, resulting in inconsistent and inadequate communication. Furthermore, issues related to

data privacy and security need to be addressed to ensure the

safe and secure use of social media platforms (Silva & Rajapaksha, 2018). Operators need to be aware of the risks associated with social media usage and implement appropriate measures to protect passenger data and privacy.

The literature also emphasizes the importance of passenger engagement and feedback in the successful implementation of social media in the public transport sector. Engaging with passengers on social media platforms can provide valuable insights into their needs and preferences, allowing operators to tailor their services accordingly. By actively seeking feedback from passengers, operators can identify areas for improvement and address any issues promptly. This engagement can also help build a sense of community and foster a positive relationship between operators and passengers.

III. METHODOLOGY

This study employs a qualitative research design to explore the use of social media by public transport operators in Sri Lanka. The qualitative approach is suitable for understanding the experiences, perceptions, and attitudes of bus operators and passengers regarding social media usage. This methodology allows for an in-depth exploration of the issues and provides rich, detailed data that can inform the development of practical recommendations.

Data were collected through focus group interviews with bus operators and passengers. A purposive sampling method was used to select participants.

A total of 55 private bus operators operating long-distance services from Colombo were selected, along with 15 randomly selected passengers. The interviews were conducted between December 2023 and March 2024. The focus group interviews were guided by a semi-structured interview guide, which included questions related to the use of social media, challenges faced, and suggestions for improvement. The interviews were audio-recorded and transcribed for analysis.

Thematic analysis was used to analyze the data. This method involves identifying, analyzing, and reporting patterns (themes) within the data. The themes were identified based on the research objectives and the theoretical framework. The data were coded and organized into themes using qualitative data analysis software. The use of thematic analysis allows for a systematic and rigorous examination of the data, ensuring that the findings are grounded in the participants' experiences and perspectives.

The study focuses on private bus operators in Colombo who operate long-distance services. This specific focus allows for a detailed examination of the issues faced by these operators and the potential benefits of social media usage. The inclusion of passengers in the study provides a comprehensive understanding of the passenger experience

and expectations regarding social media usage by bus operators.

The purposive sampling method ensures that the participants selected for the study have relevant experience and knowledge related to the research topic. By selecting bus operators who operate long-distance services from Colombo, the study captures a diverse range of experiences and perspectives. The inclusion of randomly selected passengers adds to the diversity of the sample and provides valuable insights into passenger expectations and experiences.

The semi-structured interview guide allows for flexibility in the interviews, enabling the researcher to explore new and emerging themes while ensuring that the key research questions are addressed. The use of audio recording and transcription ensures that the data collected is accurate and reliable. The thematic analysis provides a systematic and rigorous approach to data analysis, ensuring that the findings are grounded in the participants' experiences and perspectives.

III. Findings and Analysis

The analysis of the interview data revealed several key findings regarding the use of social media by public transport operators in Sri Lanka. The tables below summarize the frequency of mentions, representative quotes, thematic analysis, and the identification of existing issues based on the interview evidence. These tables provide a structured overview of the qualitative data, illustrating the common themes and challenges identified during the research.

A. Interview Evidence with Frequency and Interview Quotes

Table 1. Frequency of mentions of various themes

Theme	Frequency of Mentions	Representative Quotes
Awareness	45	"We have heard of social media but don't see how it can help our business."
Cost Concerns	38	"We can't afford to spend money on social media when we barely make enough from ticket sales."
Passenger Expectations	25	"I would like to see updates on Facebook or Twitter about bus schedules and any delays."

Misinformation	20	"Sometimes the information on social media is not updated, and we end up missing our bus."
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Technical Challenges	18	"We don't have the technology or the skills to manage social media properly."
Training Needs	15	"If we are trained on how to use social media effectively, we might consider it."

Source: By Author

Table 1 provides a comprehensive overview of the key themes identified during the interviews. The frequency of mentions and representative quotes highlight the common challenges and perceptions of social media usage among bus operators and passengers in Sri Lanka. This evidence underscores the need for increased awareness, training, and resources to improve social media adoption in the public transport sector.

B. Thematic Analysis with Interview Evidence

Table 2. Thematic Analysis with Interview Evidence

Theme	Interview Evidence	Interpretation
Awareness	"We have heard of social media but don't see how it can help our business."	Operators lack awareness of the potential benefits of social media, viewing it as non-essential.
Cost Concerns	"We can't afford to spend money on social media when we barely make enough from ticket sales."	Financial constraints are a significant barrier to social media adoption.
Passenger Expectations	"I would like to see updates on Facebook or Twitter about bus schedules and any delays."	Passengers have high expectations for timely and accurate information on social media.
Misinformation	"Sometimes the information on social media is not updated, and we end up missing our bus."	The dissemination of outdated or incorrect information on social media leads to passenger frustration and mistrust.
Technical Challenges	"We don't have the technology or the skills to manage social media properly."	Lack of technical expertise and resources hinders the effective use of social media.
Training Needs	"If we are trained on how to use social media effectively, we	There is a need for training programs to equip operators with the necessary skills

	might consider it."	to use social media effectively.
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Source: By Author

Table 2 offers a detailed thematic analysis, providing a deeper understanding of the key themes identified during the interviews. The interview evidence supports the interpretation of each theme, highlighting the specific challenges and barriers to social media adoption in the public transport sector in Sri Lanka. This analysis underscores the need for targeted interventions to address these issues.

C. Findings of Existing Issues

Table 3. Findings of Existing Issues

Issue	Key Themes	Examples from Interviews
Lack of Awareness	Awareness	"We have heard of social media but don't see how it can help our business."
Financial Constraints	Cost Concerns	"We can't afford to spend money on social media when we barely make enough from ticket sales."
Inaccurate Information	Misinformation	"Sometimes the information on social media is not updated, and we end up missing our bus."
Technical Limitations	Technical Challenges	"We don't have the technology or the skills to manage social media properly."
Training Deficiencies	Training Needs	"If we are trained on how to use social media effectively, we might consider it."
Passenger Expectations	Passenger Expectations	"I would like to see updates on Facebook or Twitter about bus schedules and any delays."

Table 3 provides a summary of the existing issues related to social media usage in the public transport sector in Sri Lanka. The categorization of issues into key themes, along with specific examples from the interviews, highlights the multifaceted nature of the challenges faced by bus operators. This summary emphasizes the need for comprehensive strategies to address these issues and improve social media adoption and usage in the sector.

D. Expectations of Social Media between Passengers and Service Providers

The cross-case analysis reveals significant differences in the expectations of social media usage between passengers

Table 4 Expectations of Social Media between Passengers and Service Providers

Theme	Passengers' Expectations	Service Providers' Expectations
Timeliness and Accuracy	Passengers expect timely and accurate updates on bus schedules, routes, and delays.	Service providers acknowledge the need for timely updates but struggle with maintaining accuracy due to resource constraints.
Information Reliability	Passengers demand reliable and consistent information to plan their journeys effectively.	Service providers recognize the importance of reliability but often provide inconsistent updates due to technical challenges.
Engagement and Interaction	Passengers desire active engagement and quick responses to queries and complaints on social media platforms.	Service providers see engagement as an additional task that requires more resources and dedicated staff.
Cost of Implementation	Passengers are unaware of the cost implications and expect free and accessible social media services.	Service providers are concerned about the high costs of social media implementation and maintenance.
Perceived Value	Passengers see high value in social media for enhancing their travel experience.	Service providers are unsure of the return on investment and are skeptical about the added value of social media.
Technical Expertise	Passengers assume operators have the technical skills to manage social media effectively.	Service providers admit a lack of technical expertise and the need for training to manage social media accounts.
Trust and Transparency	Passengers expect transparency in communication and trust the information provided on social media.	Service providers aim to be transparent but often fail due to outdated information and lack of real-time updates.
Feedback Mechanism	Passengers want a robust feedback mechanism to voice their concerns and suggestions.	Service providers see feedback as valuable but lack the systems and processes to collect and act on passenger feedback.

and service providers in Sri Lanka's public transport sector. While passengers expect timely, accurate, and reliable information along with active engagement, service providers face challenges related to resource constraints, high costs, and lack of technical expertise. Addressing these disparities requires targeted interventions such as training programs, infrastructure improvements, and cost-effective social media strategies to bridge the gap and enhance the overall public transport experience.

IV. DISCUSSION

The findings of this study indicate that the use of social media by public transport operators in Sri Lanka is still at a nascent stage. The low awareness and cost concerns among operators highlight the need for targeted interventions to promote the adoption of social media. The application of the Technology Acceptance Model (TAM) and the Diffusion of Innovations Theory provides valuable insights into the factors influencing social media adoption.

According to the TAM, perceived usefulness and perceived ease of use are critical determinants of technology adoption. In this study, the perceived usefulness of social media was low among bus operators, as they did not see it as a valuable marketing tool. This finding suggests that awareness programs highlighting the benefits of social media in improving customer satisfaction and operational efficiency could be beneficial. By demonstrating the potential advantages of social media, such as real-time communication with passengers and enhanced service delivery, operators may be more inclined to adopt it.

The Diffusion of Innovations Theory suggests that the rate of adoption of new technologies depends on factors such as relative advantage, compatibility, complexity, trialability, and observability. In the context of social media marketing, relative advantage refers to the perceived benefits of using social media over traditional communication methods. Compatibility relates to how well social media aligns with the operators' existing practices and values. Complexity refers to the perceived difficulty of using social media. Trialability is the ability to experiment with social media on a limited basis before full-scale implementation, and observability is the extent to which the results of using social media are visible to others.

The study found that bus operators perceived social media as complex and not compatible with their current practices. This perception can be attributed to the lack of technical expertise and knowledge among operators. To address this, training programs could be conducted to demonstrate the ease of use and compatibility of social media with existing communication methods. By providing operators with the necessary skills and knowledge, the perceived complexity of social media can be reduced, making it more likely for operators to adopt it.

Furthermore, the findings revealed that passengers have high expectations for social media usage by bus operators. Passengers expect accurate and timely information about

timetables, routes, and fares on social media platforms. Addressing these expectations could lead to increased passenger satisfaction and trust in the public transport system. By providing real-time updates and accurate information, operators can enhance the overall passenger experience and foster a positive relationship with passengers.

The findings also highlighted several barriers to social media adoption in the public transport sector. One of the main barriers is the perceived high cost of implementing and maintaining social media accounts. Many operators, especially those in developing countries, operate on tight budgets and may not have the financial resources to invest in social media. To address this barrier, operators need to be made aware of the potential return on investment from social media usage. By demonstrating the potential benefits, such as increased passenger satisfaction and improved operational efficiency, operators may be more willing to invest in social media.

Another significant barrier is the lack of infrastructure and resources to manage social media accounts effectively. Many public transport operators do not have dedicated staff to handle social media, resulting in inconsistent and inadequate communication. To overcome this barrier, operators need to be provided with the necessary infrastructure and resources to manage social media accounts effectively. This includes access to technology, internet connectivity, and dedicated staff for social media management.

The findings also revealed that there is a lack of training and awareness among operators regarding the effective use of social media platforms. To address this issue, training programs could be conducted to equip operators with the necessary skills and knowledge to leverage social media effectively. These training programs should cover topics such as creating and managing social media accounts, engaging with passengers, and providing accurate and timely information.

The study also identified issues related to data privacy and security, which need to be addressed to ensure the safe and secure use of social media platforms. Operators need to be aware of the risks associated with social media usage and implement appropriate measures to protect passenger data and privacy. By addressing these issues, operators can enhance the overall passenger experience and foster a positive relationship with passengers.

V. RECOMMENDATION

Based on the findings of this study, several recommendations can be made to improve social media usage in the public transport sector in Sri Lanka. Firstly, awareness programs should be conducted for bus operators to highlight the benefits of social media in improving customer satisfaction and operational efficiency. These programs should demonstrate the potential advantages of

social media, such as real-time communication with passengers and enhanced service delivery.

Training programs should be provided to bus operators on the effective use of social media platforms. The training should cover topics such as creating and managing social media accounts, engaging with passengers, and providing accurate and timely information. By equipping operators with the necessary skills and knowledge, the perceived complexity of social media can be reduced, making it more likely for operators to adopt it.

Pilot projects should be implemented to allow bus operators to experience the benefits of social media on a small scale before wider adoption. These projects can help operators understand the ease of use and compatibility of social media with their existing communication methods. By providing operators with the opportunity to experiment with social media on a limited basis, the perceived risks associated with social media usage can be reduced.

The necessary infrastructure and resources should be provided to manage social media accounts effectively. This includes access to technology, internet connectivity, and dedicated staff for social media management. By addressing the technical challenges associated with social media usage, operators can enhance the overall passenger experience and foster a positive relationship with passengers.

A feedback mechanism should be established to gather input from passengers on their expectations and experiences with social media usage by bus operators. This feedback can be used to improve the quality of information provided and address any issues promptly. By actively seeking feedback from passengers, operators can identify areas for improvement and tailor their services accordingly.

Collaboration with technology providers should be encouraged to develop user-friendly social media tools and applications tailored to the needs of bus operators. This can help simplify the process of managing social media accounts and enhance the overall passenger experience. By working with technology providers, operators can access the necessary resources and support to implement social media effectively.

A. Comparison with Other Asian Countries

In the context of long-distance bus operations, social media has proven to be a transformative marketing tool across various Asian countries. By examining successful case studies from countries like India, China, and Malaysia, Sri Lanka can gain insights into effective strategies for enhancing social media use in its public transport sector.

In India, social media has been leveraged extensively by long-distance bus operators to engage with passengers and provide real-time updates. Companies like RedBus, a leading online bus ticketing platform, use social media

platforms such as Facebook and Twitter to communicate

with their customers, provide service updates, and gather feedback. According to a study by Mitra and Nath (2017), the use of social media has helped Indian bus operators improve customer satisfaction and operational efficiency. The study highlights that timely updates on bus schedules and routes, along with interactive engagement, have significantly enhanced the passenger experience.

Similarly, in China, the integration of social media with public transport operations has been highly effective. The use of platforms like WeChat and Weibo by bus operators allows for seamless communication with passengers. These platforms are used to provide real-time information, address passenger queries, and promote special offers and discounts. A study by Zhang et al. (2018) found that social media usage in the Chinese public transport sector has led to increased passenger loyalty and trust. The ability to quickly disseminate information and interact with passengers has created a more reliable and user-friendly public transport system.

In Malaysia, the adoption of social media by long-distance bus operators has also been noteworthy. Companies like Plusliner and Aeroline actively use Facebook and Instagram to keep passengers informed about service updates and promotional campaigns. A research paper by Lim et al. (2016) indicates that Malaysian bus operators have successfully used social media to enhance brand visibility and engage with a broader audience. The study emphasizes the importance of visually appealing content and regular updates in maintaining passenger interest and satisfaction.

VI. CONCLUSION

This study highlights the current state of social media usage by public transport operators in Sri Lanka and identifies the gaps and challenges in its implementation. The findings indicate that there is a low level of awareness and perceived usefulness of social media among bus operators. Addressing the identified issues through awareness programs, training, pilot projects, and collaboration with technology providers can promote the adoption of social media and improve the overall public transport system in Sri Lanka. By leveraging social media effectively, bus operators can enhance communication with passengers, provide accurate and timely information, and ultimately increase passenger satisfaction and trust in the public transport system. The study provides valuable insights into the factors influencing social media adoption and offers practical recommendations to overcome the barriers and leverage the potential of social media in the public transport sector.

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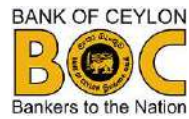
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