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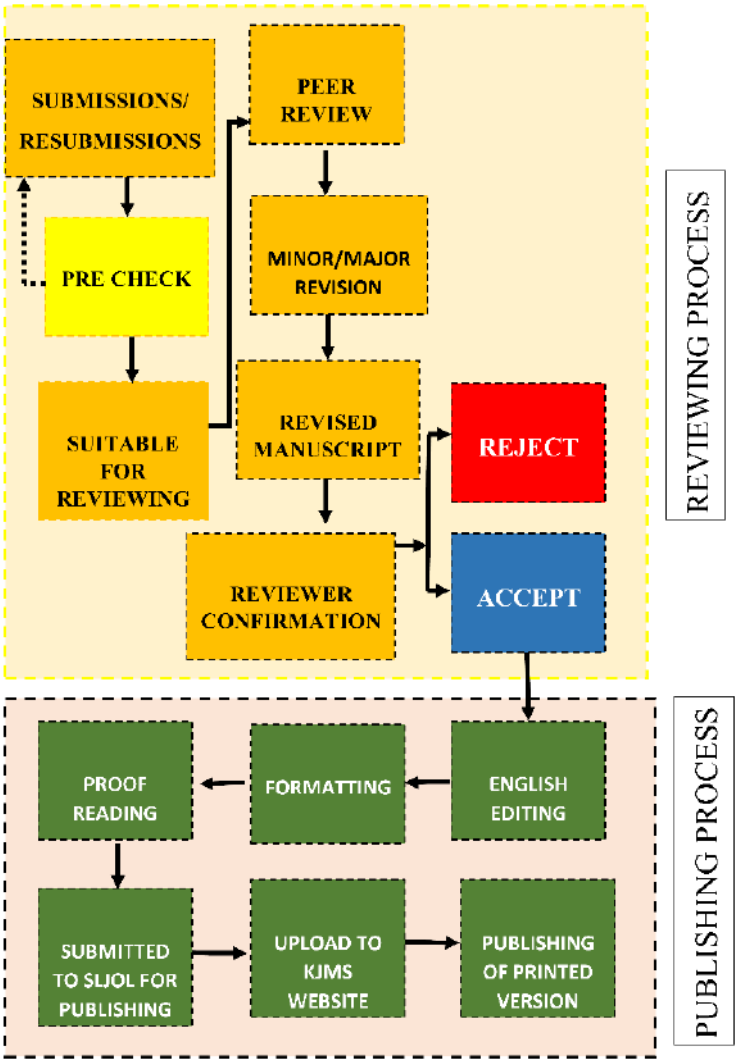

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CONTENTS

In-vitro proliferation and enrichment of CD34+ autologous haematopoietic stem cells, obtained from patients with end-stage left ventricular failure 1
P M Athauda arachchi and AI Kuruppu

Legal framework of plastic packaging and labelling in Sri Lanka: a comparative analysis 5
B.A.K.S. Balachandra and T.B. Abeysekara

Remote learning in military higher education during COVID-19: challenges and strategies for student officers in Sri Lanka 17
UVS Bandara, WS Sudusinghe and CKW Gamage

Fostering Learner Autonomy and Best Approaches to Implement the Practice 25
Saumya Batuwatta and C.D.H.M. Premarathna

Protection of Geographical Indications (GI) in Sri Lanka:
A Critical Legal Analysis 35
H.L.N.S Chandrasiri

Hyposense: an integrated sensor device for hydroponics farm monitoring 43
H. L. Hasith Deshan, K. T. Y. Mahima, M. P. C. K. Divyanjalee, Thilini A. Perera, Damitha Sandaruwan, L. N. C De Silva, R. Pushpannda, C. I Keppitiyagama and T. N. K. De Zoysa

Estimation of CLARK Y-14 Airfoil's Lift Hysteresis in Low-Speed Flow 55
WARD Jayathilake and JI Abeygoonewardene

Competitiveness of Sri Lankan Tea in the International Market: A Trade Flow Analysis 62
Tharindu Udayanga Kamburawala and Dilmini Hasintha Abeyrathne

Depression, Anxiety, and Stress among Allied Health Sciences undergraduates: A cross-sectional Study at a Defence University in Sri Lanka 72
Kithmini JPD, Kaarthiga S, Perera VBJ, Deshapriya HDS, CKW Gamage and Fernando NFJ

Towards a paradigm shift with neuro-entrepreneurship education: a lesson for the developing Asian nations 81
A. Mithursan, N.T.K.P. Fernando, D.I.J. Samaranayake and S. Maheswaran

The effect of z-score on Year Grade Point Average (YGPA) and Final Grade Point Average (FGPA) in Faculty of Engineering, General Sir John Kotelawala Defence University (KDU) 95
Nawarathne N. G. S. A, Nawarathne N. G. R. M. and Udara W. I. N.

The Concept of 'Inventiveness of Machines': How Ready is Patent Law to Afford the Creative Inventiveness of Artificial Intelligence? 106
Ruwini Uthpala Nissanka

Secondary school Adolescents' knowledge of Corruption in Nigerian Society: Implications for Counselling and Value Reorientation 118
Olatunji, M. O and Shobayo, M. A

Factors influencing the use of Point Of Care Ultrasound (POCUS) on adult patients by Accident and Emergency department (A&E) doctors in tertiary care hospitals in Colombo district, Sri Lanka; a descriptive cross-sectional study 126
MDRM Piyasiri and Chamali Anuttara

Enhancing thermal and daylight performance of historic buildings with passive modifications; A tropical case study 134
Malthi Rajapaksha, M. Kariyakarawana and R U Halwatura

Adopting ISO 9001:2015 & ISO 21001:2018 EOMS to the Sri Lankan Higher Educational Institutions: A Review of Literature 145
WKD Ramese, SD Jayasooriya and AH Lakmal

Socio-economic implications of domestic violence in Thenmaradchi Divisional Secretariat in Jaffna District 158
G. Sarththiga and S. Sivakanthan

PERMA profiler: Adaptation to Sinhala 170
T.H. Solomons[1], S. Katriarachchi, J. Galante and D. Waas

Integrating socio cultural theory and bloom's taxonomy to overcome xenoglossophobia and anxiety in English language speaking in Sri Lankan undergraduates 177
MTN Wijetunge

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KJMS 2024 VOL.6 (1):1-4

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IN-VITRO PROLIFERATION AND ENRICHMENT OF CD34+ AUTOLOGOUS HAEMATOPOIETIC STEM CELLS, OBTAINED FROM PATIENTS WITH END-STAGE LEFT VENTRICULAR FAILURE

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ABSTRACT

With a rising global prevalence of end-stage heart failure and a limited availability of cardiac transplantation programmes or left ventricular assist devices in many parts of the world, there is a renewed interest in potential alternative treatment options.

Along with other groups, we have previously demonstrated the beneficial effect of intracoronary autologous bone marrow derived peripheral haemopoietic stem cell transplantation, to improve myocardial contractility in end-stage heart failure.

We now assess the ability of these cells to expand in numbers in-vitro, to achieve enrichment of stem cell counts, using standard cell culture methods and flow- cytometric analysis.

We demonstrate that with in-vitro culturing (within 3 passages post-harvest), the CD34+ stem cell fraction increases in standard culture media, across multiple samples. However, optimal culture conditions to achieve near pure stem cell populations with rapid cell proliferation, still needs to be defined.

KEYWORDS: *End-stage heart failure, Intra-coronary Transplantation, Autologous bone-marrow-derived peripheral haematopoietic stem cells.*

ABBREVIATIONS: *DMEM: Dulbecco's Modified Eagle Medium, FCS: Foetal Calf Serum, CD34+: Cluster of Differentiation 34 positive, FACS: Fluorescence-activated cell sorting, WBC: white blood cells.*

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1. INTRODUCTION:

The global prevalence of end-stage heart failure is rising, despite the presence of successful reperfusion strategies for acute myocardial infarction, improved pharmacological and device therapy for heart failure. The changing demographics and disease onset at a young age and longer survival may paradoxically be contributing to this observation in both developed and developing countries. The limited availability of cardiac transplantation programmes and absence of left ventricular assist devices in many parts of the world, has renewed interests in potential alternative options, for treating patients with end stage heart failure (Athauda-arachchi 2019).

Haematopoetic stem cells derived from bone marrow have been used for autologous transplantation since (Barnes et al 1956) for haematological cancers. Many groups, including ours (Athauda arachchi 2022) have previously demonstrated the beneficial effect of intracoronary autologous bone marrow derived peripheral haemopoietic stem cell transplantation, to improve myocardial contractility post-MI (Schächinger 2004) or in end-stage heart failure (Schächinger et al 2006).The harvesting techniques and utility of these cells in many other conditions have been widely described (Snowden et al 2018, Mahla 2016 and Burt et al 2008).

However, it is not known whether these cells when taken in-vitro, could exhibit rapid proliferation and yield enriched stem cell populations, using standard cell culture media.

With this initial study, we aimed to assess the potential for in-vitro expansion of peripherally derived autologous haematopoietic stem cells.

2. METHODS

Two 1 ml samples of bone marrow derived peripheral haemopoietic stem cells, obtained as voluntary donations from patients with severe heart failure, undergoing autologous intra-coronary stem cell infusion, was transported on ice, and used for culture in DMEM, 1% penicillin/streptomycin, 20% FCS. The nutrients the medium includes glucose, L-glutamine and sodium pyruvate (contained in DMEM) and mixture of macromolecules, including hormones, transport proteins, growth factors, lipids, minerals, elements, and detoxifying factors conferred by 20% FCS.Cells were seeded at densities of approximately 1million per ml in T25 flasks. They were incubated in 5% CO_2 and at 37^{o} C and passaged three times into new media every 48 hours. Cells were analysed morphologically, by Trypan blue exclusion assay and by flowcytometry, for the presence of CD34 surface marker (with external validation of result at Sri Jayewardenepura Hospital, Colombo), indicative of "stemness" of the hematopoietic cells, before (passage 1) and after culturing (passages 2 & 3).

3. RESULTS

The morphology of the cells under microscope is demonstrated in figure 1. Immediately after counting in haemocytometer, seeding into the T25 flasks (passage 1), they appear somewhat aggregated, becoming less dense clusters and individual cells

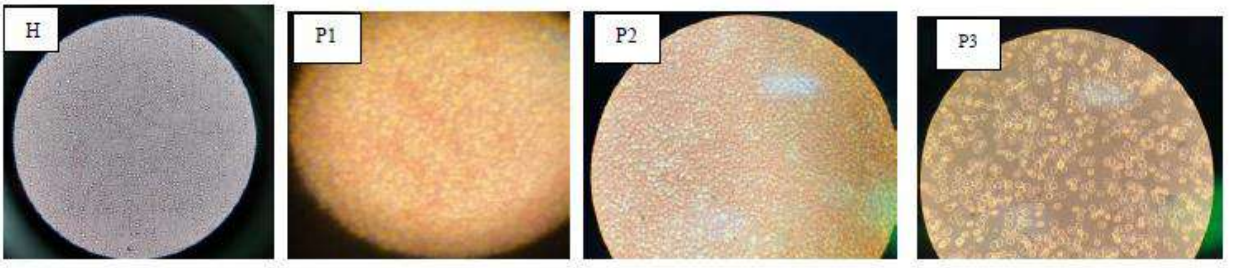

Figure1: Microscopic appearance of hematopoietic stem cells at haemocytometry [H], initial seeding to culture [p1] medium, and follow up of passages [p2 & p3].

later (passage 3). Trypan blue exclusion assay demonstrated >80% live cells after 3rd passage.

At the point of collection, total WBC numbers was approximately $219.5X10^3$ and $203x10^3$ cells per microlitre and contained approximately 1.8% and 8.2% CD34+ cells. Following serial passaging in tissue culture media, the CD34+ve cell counts could be increased to 12.7% after second passage and up to 59.1% by third passage, in one sample and up to 15% in the other, albeit the overall cell number decreased, indicating a preferential survival of the stem cell progeny in the cultures (Table 1) and loss of other cells. It also highlights, a difference in the hematopoietic stem cell numbers collected between individuals, and variabilities in the potential to enrich CD34+ stem cells by culture.

Table 1: Comparison of CD 34+ve cell counts by flow cytometry (FACS)- initial sample [p1], and of passages [p2 & p3], showing differences between the samples of the two subjects

	Subject	Initial counts(P1) cells /µl	Passage 2 cells /µl	Passage 3 cells /µl
Total WBC	1	$219.5X10^3$	$1.34x10^3$	$0.8X10^3$
	2	$203X10^3$	-	$0.27x10^3$
CD45 -ve %	1	1.8%	16.1%	59.6%
	2	8.2%	-	21.8%
CD34+ve% (out of CD45-ves)	1	75.1%	78.8%	99.3%
	2	48.1%	-	69%
CD34+ve% (out of total WBC)	1	1.35%	12.69%	59.18%
	2	3.9%	-	15.04%

4. DISCUSSION AND CONCLUSIONS

Peripherally derived autologous haematopoietic stem cells, hitherto harvested from patients with end-stage heart failure used for intracoronary infusion, may also be successfully passaged in tissue culture flasks using simple culture conditions. Here we described conditions, devoid of added growth factors or cytokines, to maintain the progenitor identity over several passages. The CD 34+ cell percentage in this simple culture technique rises due to stem cell survival/proliferation, with loss of other cells. It is also not certain how many passages the CD34+ autologous haematopoietic stem cells can be enriched this way, without terminal differentiation.

Many contemporary culture media different to ours have been described with different conditions to propagate hematopoetic stem cells (Yadav et al 2020), noting that the final lineage specification can substantially depend on the culture conditions.

The challenge is to standardize a culture system that can predictably enrich the CD34+ hematopoietic stem cell population, with the ideal composition of growth and survival factors. Chemically defined media (CDM) Joannides et al (2007) has previously been described for embryonic stem cell proliferation, but it is not certain whether such culture media which are morphogen free, may be more suitable for achieving higher cell survival and enrichment of CD 34+ hematopoetic stem cells. Further studies are indicated to test such media.

Refining these methods in future, and testing samples from more donors, enables to identify best methods for ex-vivo expansion and storage of peripherally derived autologous haematopoietic stem cells for potential "individualised cell therapy" of end-stage left ventricular failure for a given patient.

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LEGAL FRAMEWORK OF PLASTIC PACKAGING AND LABELLING IN SRI LANKA: A COMPARATIVE ANALYSIS

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ABSTRACT

Plastic packaging plays a pivotal role in delivering quality products to consumers but poses significant waste management challenges once discarded. Landfilling, the primary method for solid waste disposal in Sri Lanka, exacerbates plastic pollution due to poor waste separation, leading to environmental contamination and health hazards. Mismanaged plastic packaging waste also threatens key industries like tourism, fisheries, and agriculture, endangering the country's economy and biodiversity. This research utilized secondary data to examine plastic packaging waste regulations, incorporating expert strategies such as the circular economy and extended producer responsibility. An extensive literature review, including German and EU directives, identified effective waste management practices, while primary data on food packaging was collected through observation to propose improved labelling regulations for Sri Lanka. The findings recommend mandatory labelling by manufacturers to inform consumers about the recyclability and quantity of plastic packaging, promoting awareness and sustainable consumption. Additionally, implementing eco-labelling and legislation for plastic packaging in Sri Lanka will enhance waste separation, recycling, and recovery, reducing plastic pollution and mismanaged waste.

KEYWORDS: *Plastic Pollution, Plastic Packaging Labelling, Producer Responsibility*

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1. INTRODUCTION

1.1 background of the study

Landfilling, the most common solid disposal option worldwide, has been practiced for more than 70 years. Sanitary landfills offer the most cost-effective solution for disposing of non-recyclable waste. Karadiyana garbage dump, Katunayake Seduwa Urban Council dump yard, and Deldorawatta garbage recycling center are the most identified solid waste landfills in Sri Lanka. However, there are approximately 330 landfills and open dumping sites in Sri Lanka. These would only make people produce more waste not less and the problem will never get resolved with the increase of the population.

Landfill areas contain many different types of plastics. Most of the waste in the form of plastic in landfills is single-use items such as packaging and due to lack of separation of waste, there is a risk of contaminating the hazardous waste in the residual waste.

The best solution to tackle the overflow of plastic pollution in landfills is to focus on preventing and reducing the generation of plastic in the first place. Manufacturers keep on producing plastic packaging products for profit and consumers just buy them without any effort to change their lifestyle, which has become a problem. The issue lies with the creation of plastic packaging, rather than with the waste generated from plastic packaging.

The most common single-use plastic packaging identified are plastic water bottles and shopping bags. Experts have revealed that the poor segregation of waste and poor disposal and collection systems have created a risk of contaminating hazardous waste with residual waste, which causes leaching chemicals into underground waters even through a sanitary landfill. Landfills cause a risk of groundwater intoxication. Toxic chemicals that have high concentrations of nitrate and phosphate derived from the waste in the soil can filter through the dump and contaminate both the ground and surface water (Akinbile, 2012). This will not only negatively affect human health but also harm the ecosystem in Sri Lanka, posing a threat to biodiversity.

Further, it is identified that most landfills and open garbage dump sites cause air pollution as a result of the burning of post-consumer plastic packaging waste. When the plastic packaging in landfills are burnt, toxic fumes are released to the environment. Packaging made from non-renewable resources can cause long-term pollution of the environment, including air and soil, and may contain environmentally damaging chemicals, which can have serious effects on human health (Scipioni, 2012). Given the various types of plastic waste packaging, not all post-consumer products can be recycled. Therefore, it should be emphasized that the manufacturer's responsibility is crucial for the sustainability of the product material.

According to Al-Salem, Lettieri & Baeyens (2009), a significant downside of landfills from a sustainability perspective is that none of the material resources used in plastic production are recovered, resulting in a linear material flow rather than a cyclic one. According to the EU Council Directive 1999/31/EC on the landfill of waste, landfilling in Europe is limited to inert materials that are not biodegradable or combustible on a national level. (Mou, 2014)

These identified problems are still in existence due to inadequate regulations on plastic packaging waste. Mismanaged plastic packaging wastes are rapidly increasing when smaller percentages of plastic packaging wastes are recycled and the rest go to the landfills and the environment.

Proposed policy regulation on manufacturers and distributors will make consumers do the right thing whenever they are at home or on the roadside rewarding good behaviors. The proposed regulations aim to protect consumers by reducing unnecessary packaging costs for manufacturers and distributors, which in turn will contribute to poverty reduction in Sri Lanka.

It is expected that the findings of this research will focus on policymakers making decisions wisely when implementing regulations on plastic waste management. Regulations on package labelling will not only benefit the Central Environment Authority, Western Provincial Waste Management Authority, Supportive Unit and Local Authorities but also the business organisations and the community as a whole. Prevention of waste at generation through regulations will be focused on in this research highlighting the responsibility of the product manufacturer and will inevitably be a guiding principle for awareness of the packaging waste problem.

Accordingly, this paper intends to identify gaps existing in regulations on plastic waste management in Sri Lanka, with special emphasis on strict separation of plastic waste at source. The main problem examined in this paper is on how to implement a regulation on the manufacturer for the responsibility of the product packaging. The resources that become "plastic packaging waste" thus need to be more concerned and redirected in the production process by the manufactures.

Therefore, it is necessary to implement regulations, recommendations, and best practices to transition from a throwaway society to one that emphasizes greater recycling, repair, reuse, and reduction of plastic packaging waste. The proposals and recommendations made in this research paper will guide and shape the implementation plan for plastic packaging waste policies, encouraging businesses to act responsibly and rewarding good behavior among consumers.

1.2 literature review

Labels on products are powerful marketing tools (Treves & Jones, 2010) that act as essential communication conveyers between businesses, public authorities and consumers (Struwig & Adendorff, 2018). Eco-labels convey to consumers a sense of environmental consideration on the part of the manufacturer (Koos, 2011). As per Eco Label Index (2015), there are estimated 463 types of eco labels, across 199 countries and 25 industry sectors (Eco Label Index, 2019). These eco-labels are managed either voluntarily or mandatorily with the support of governments, companies, and non-governmental organizations (Senaweera & Parasnis, 2018).

The ISO 14000 is an Environmental Management System (EMS) standard developed by the International Organization for Standardization (ISO) Technical Committee ISO/TC 207 and its various subcommittees (International Organization for Standardization, 2019). According to some findings, presumably, organizations that had implemented the ISO 14001 have succeeded in decreasing the amount of waste produced (Sroufe, 2003) and tend to reduce costs compared to their previous consumption or production (Penttilä, 2016).

1.2.1 International Standards on Eco-Labelling

1. ISO 14020

The Environmental Labelling General Principles standard outlines nine fundamental principles applicable to all environmental claims and labelling schemes. These principles are aimed at ensuring the provision of accurate, verifiable, and relevant information across the board, fostering transparency and reliability in environmental communications.

2. ISO 14021

The Environmental Labels and Declarations standard encompasses Self-Declaration, Environmental Claims, Terms, and Definitions, establishing requirements for Type II labels. These labels pertain to environmental claims made by producers about their goods and services.

3. ISO 14022

The Environmental Labels and Declarations framework, specifically Environmental Labelling Type I, lays out the guiding principles and procedures necessary to create programs that verify the environmental characteristics of a product. These programs typically include the issuance of a seal of approval, which serves as an indication that the

product complies with particular environmental standards and criteria.

4. ISO 14024

The Environmental Labels and Declarations framework, particularly Environmental Labelling Type I, provides guiding principles and procedures to develop programs that verify a product's environmental attributes. These programs often involve issuing a seal of approval, indicating that the product meets specific environmental standards and criteria.

5. ISO 14025

Environmental labels and declarations, specifically Type III environmental declarations, establish principles and procedures for providing quantified environmental information about products. These declarations are based on life-cycle data and are aimed at informing consumers and stakeholders about the environmental impact of products throughout their life cycle. These principles and procedures help standardize the process of issuing such declarations, ensuring consistency and reliability in the information provided.

The International Organization for Standardization (ISO) has classified these Eco-labels into three types according to principles, practices and key characteristics: Types I, II and III.

It is identified in a study and recommended for introducing a well-recognized internationally accepted product-based Eco label which considers the whole life cycle of a product. The study revealed that introducing eco labels promote the greening of the supply chain and competitiveness in the international markets (Senaweera & Parasnis, 2018). However, the study has not recommended adopting a green dot packaging labelling system in Sri Lanka for manufacturers from an organization for the recyclability or recoverability of plastic packaging waste.

Table 1 gives the summary of the eco-labelling systems available in Sri Lanka as identified through the literature findings.

1.2.2 Eco-labelling schemes available in Sri Lanka

Legal Framework for Labelling Schemes in Sri Lanka

National Environmental (Plastic Material Identification Standards) Regulations No.1 of 2021 implemented through Special Regulation No.2211/50. The regulation states, "any manufactured plastic item shall be marked clearly under the plastic material identification standards specified in the schedule" (S.R., No.2211/50).

Table 1

PLASTIC MATERIAL IDENTIFICATION STANDARDS

Column I	*Column II*	*Column III*		
Material	*Abbreviation of the material*	*Symbol options*		
		1	2	3
(1) Polyethylene terephthalate	PET or PETE	01 PET	1 PETE	1
(2) High-density polyethylene	HDPE or PE-HD	02 PE-HD	2 HDPE	2
(3) Polyvinyl chloride	PVC or V	03 PVC	3 V	3
(4) Low-density polyethylene, Linear low-density polyethylene	LDPE or PE-LD	04 PE-LD	4 LDPE	4
(5) Polypropylene	PP	05 PP	5 PP	5
(6) Polystyrene, expanded polystyrene, Styrofoam	PS	06 PS	6 PS	6
(7) Other plastics, such as acrylic, nylon, polycarbonate, and multilayer combinations of different plastics	OTHER or O	07 OTHER	7 O	7

Source: National Environmental (Plastic Material Identification Standards) Regulations No.1 of 2021 implemented through Special Regulation No.2211/50

Plastic Material Identification Standards

However, the regulation has failed to address the issue of distributors who are equally responsible in Sri Lanka for post-consumer plastic packaging waste. Because National Environmental (Plastic Material Identification Standards) Regulations No.1 of 2021 only apply to the manufacturer, therefore the regulation has been ineffective in managing plastic packaging waste in Sri Lanka. Extraordinary Gazette No.2211/51 has prohibited.

Labelling Schemes available in the German Jurisdiction

The EU Directive 1994/62 on Packaging and Packaging Waste aims to harmonize packaging waste management across member states, promoting recycling and minimizing environmental impact. However, national regulations like Germany's Verpackungsgesetz (Packaging Act) impose stringent standards, potentially conflicting with the Directive's goal of uniformity and increasing compliance costs for businesses operating in multiple EU countries. This highlights the tension between EU-wide regulatory harmonization and national sovereignty.

Comparatively, Sri Lanka's packaging laws, governed by the National Environmental Act and the Consumer Affairs Authority Act, focus on reducing pollution and promoting sustainable practices. These laws mandate recyclability labelling and restrict hazardous materials, but are less complex and more centralized than the EU's fragmented regulatory landscape. While the EU faces challenges in balancing uniformity and sovereignty, Sri Lanka's straightforward regulations provide clearer business guidelines but may lack the comprehensive rigor of the EU Directive. Sri Lanka could enhance its packaging waste management by adopting elements from the German model, balancing stringent measures with local economic capacity to foster environmental sustainability.

The certification given under the green dot system will force the manufacturer to produce their packaging to improve the material resource efficiency of the packaging material. This system will monitor and minimize the plastic packaging waste disposed in landfills in Sri Lanka.

1.3 Theory of the study

Extended Producer Responsibility (EPR) is an environmental policy approach that holds producers accountable for the entire lifecycle of their products, particularly focusing on the take-back, recycling, and final disposal of products. The core principle of EPR is that manufacturers should bear the financial and/or physical responsibility for the environmental impacts of their products from design through end-of-life. This shifts the burden of waste management from governments and taxpayers to producers, incentivizing them to design more sustainable products.

1.4 Research gap

Identifying the gaps in the current plastic packaging waste management system in Sri Lanka highlights several critical areas where improvements are needed. There is a significant gap in consumer knowledge about the different types of plastics, their recyclability, and proper waste separation methods. Many consumers are unaware of how to correctly dispose of plastic packaging, leading to improper waste handling. There is a need for more robust educational campaigns and programs to inform the public about the importance of proper waste segregation and recycling practices.

The diversity of plastic types used in packaging complicates the waste separation process at the source. Consumers often find it difficult to distinguish between recyclable and non-recyclable plastics. There is a lack of adequate infrastructure and systems to facilitate efficient waste separation at the source, which is crucial for effective recycling.

Existing regulations on plastic waste management may be insufficient or inadequately enforced. There is a need for stronger policies and stricter enforcement to ensure compliance with waste management protocols. There is a lack of incentives for producers and consumers to adhere to waste management regulations, which hinders the effectiveness of these policies.

The current recycling facilities in Sri Lanka may be inadequate to handle the volume and variety of plastic waste generated. This limits the overall capacity for recycling and recovery. The processes used in recycling facilities may not be efficient or advanced enough to handle the complexities of different plastic types, resulting in lower recycling rates.

Improper waste separation leads to the contamination of hazardous waste with residual waste. This renders sanitary landfills ineffective, posing serious

environmental and health risks. Contaminated waste can lead to chemical leakage into the soil and water sources, impacting the food chain and human health.

Mismanagement of plastic packaging waste negatively affects key industries such as tourism, fisheries, and agriculture, which are vital to Sri Lanka's economy. The economic burden of ineffective waste management is high, affecting public health, environmental quality, and the overall sustainability of industries. The environmental impact of plastic pollution includes significant biodiversity loss, as both marine and terrestrial ecosystems are affected by plastic waste. The pervasive pollution of oceans and land by plastic waste underscores the urgent need for improved waste management strategies to protect the environment.

There is a gap in the implementation of Extended Producer Responsibility (EPR) programs, which could hold producers accountable for the lifecycle of their products, including take-back, recycling, and disposal. There is insufficient engagement and participation from producers in managing the end-of-life disposal of their products.

1.5 Research questions

1. What are the key components of Germany's legal framework on plastic packaging and labelling?
2. What are the current legal and regulatory frameworks governing plastic packaging and labelling in Sri Lanka?
3. How do the regulatory approaches of Germany and Sri Lanka compare regarding plastic packaging and labelling?
4. What specific policy recommendations can be derived from Germany's experience to enhance plastic packaging and labelling regulations in Sri Lanka?

1.6 Objectives

1. To analyze Germany's legal framework
2. To assess the current legal and regulatory environment in Sri Lanka
3. To compare and contrast legal approaches
4. To propose policy and regulatory recommendations for Sri Lanka

1.7 Significance of the study

Plastic packaging plays a pivotal role in delivering quality products to consumers. However, once its purpose is served, it becomes waste, posing significant challenges due to the diverse types of plastics used, which complicate waste separation at the source. The lack of awareness among private consumers regarding plastic types, recyclability, and recovery exacerbates the issue. Improper waste separation by consumers leads to the contamination of hazardous waste with residual waste, which renders sanitary landfills ineffective in managing the waste properly. This can result in chemical leakage into the soil, contaminating water sources and impacting the food chain, thereby affecting human health.

The mismanagement of plastic packaging waste also threatens key industries such as tourism, fisheries, and agriculture, endangering the country's economy. Additionally, the environmental consequences, including biodiversity loss and pollution of oceans and land, underscore the urgent need for improved plastic packaging waste management in Sri Lanka. Addressing these challenges is crucial to protect both the environment and the economy from the adverse effects of plastic waste.

2. METHODOLOGY

This research was based on secondary data. Literature was not limited to finding regulations on plastic packaging waste but it also extends to finding the best

strategic system as per the experts' views such as circular economy, cradle-to-cradle design, extended producer liability, stewardship and pay you as you-through.

Literature was collected to ascertain the existing legal framework governing the labelling of plastic packaging in Sri Lanka. This research paper considered options across the field of waste, recognizing that there are many lessons we can learn from Germany; a country that recycles at least half of its municipal waste (European Environment Agency, 2018). Further research focused on the directives of the European Union as the directives have had been the base for the regulation implemented by Germany.

An extensive literature review was conducted by referring to secondary sources which are available online such as legislation, books, journal articles, working articles, dissertations, research data, web pages, newspapers, and scientific papers to identify the plastic packaging labelling regulations in Germany for the last decade.

Data collection was done through both secondary and primary sources. The primary data related to this phase was collected mainly through observation on different food packaging.

The literature review identifies the existing waste management regulations and practices under German law and proposes regulations to adopt the best strategies for enhancing current packaging labelling practices to achieve zero waste management goals.

3. RESULTS AND DISCUSSION

From a legal perspective, the concept of zero waste as advocated by Zero Waste Europe presents several challenges and opportunities. Firstly, the shift from conventional waste management practices, which are typically designed for a linear economy, raises questions about the legal frameworks governing waste disposal and recycling. In many jurisdictions, waste management laws focus on disposal methods such as landfilling and incineration, which may not align with the goals of zero waste strategies. Therefore, there may be a need for legislative amendments or new regulations to promote and incentivize zero waste practices.

One key aspect highlighted is the responsibility of manufacturers in labelling products for recyclability and sustainability. This intersects with existing consumer protection and environmental regulations that mandate accurate labelling and disclosure of product information. Manufacturers may be legally required to provide clear and verifiable information about the recyclability and sustainability of their packaging, ensuring that consumers can make informed choices.

Although plastics are technically recyclable most of them are not recyclable due to the infrastructure that does not exist in those packaging. Several major factors are limiting the effectiveness of plastics recycling. Recycling of single resins is limited by the lack of ability to separate a mixture of plastic easily (such as those collected at the curbside). Therefore, the separation of waste at source plays a major part in this issue.

Furthermore, the discussion on technological advances in recycling and life-cycle analysis (LCA) underscores the importance of incorporating scientific and technical data into waste management policies. Legal frameworks may need to encourage research and development in recycling technologies, while also mandating LCA assessments for certain products to quantify their environmental impacts. A recent LCA specifically for *Polyethylene Terephthalate* (PET) bottle manufacture calculated that the use of 100 percent recycled PET instead of 100 percent virgin PET would reduce the full life-cycle emissions from 446 to 327 g CO2 per bottle, resulting in a 27% relative reduction in emissions (Gomes, Visconte & Pacheco, 2019).

The mention of toxic additives and hazardous chemicals in plastic packaging manufacturing raises regulatory concerns regarding product safety and environmental protection (Groh et al 2019). Laws governing the use of chemicals in manufacturing, such as restrictions on hazardous substances or requirements for safer alternatives, play a crucial role

in mitigating risks associated with packaging materials (Ong, Samsudin, & Soto-Valdez, 2020).

Making of plastic packaging may incorporate the use of toxic additives and hazardous processing chemicals. For example; Separation from polyvinyl chloride (PVC) is important in PET recycling processes due to its toxicity, which degrades the final quality of recycled PET (Galdón-Navarro et al, 2018). Unnecessary multi-layered packaging and non-recyclable plastic packaging are problematic and this type of packaging need to be restricted by implementing regulations on the packaging.

Manufacturers are responsible for producing the post consumed disposable plastic packaging waste, something at the end of its life cycle will end up in the trash bin. However, one must consider the fact that the recyclable product which end up in the trash bin must be recycled, and there is no other alternative for this problem. Packaging waste regulations have the ability to make manufacturers produce resource efficient packaging. By registering under a licensing body manufacturers should design their packaging by minimizing its harmfulness and its packaging quantities.

Waste minimization involves efforts to avoid creating waste during manufacturing. To effectively implement waste minimization, the manufacturer requires knowledge of the production process, cradle-to-grave analysis (the tracking of materials from their extraction to their return to earth) and details of the composition of the waste.

Regarding waste minimization and extended producer responsibility (EPR), legal mechanisms such as waste disposal taxes, deposit refund schemes, and EPR regulations can incentivize manufacturers to adopt sustainable practices. These instruments shift the financial burden of waste management onto producers, encouraging them to design products for easier recyclability and to minimize waste generation throughout the product lifecycle.

Manufactures who produce post-consumer plastic packaging waste that end up in land fill must be charged with a landfill tax. Due to this reason the cost of product will be increased and this will discourage the consumer to buy products packed with plastic packaging and inevitably the consumer will tend to look for sustainable products.

Packaging of Chocolate Bar

Packaging of peanut butter jar

Figure 1: Packaging of products Manufactured in Australia

As per the above findings, waste generation and handling are a critical issue. Thus, it is important to implement the zero-waste management system to avoid waste problems. According to the literature findings, the design of the packaging is the best place to implement zero waste. Therefore, this research was considered about the manufacturing stage to prevent the generation of waste. Thus, this research was focused on applying the concept of zero waste to the manufacturing industry in Sri Lankan context.

Economic instruments are implemented through national or regional waste policies, such as waste disposal taxes, waste pricing, deposit refund schemes, extended producer responsibility, tradable

permits, recycling subsidies, value-added tax (VAT) exemptions for repair and recycling activities, etc. (Morlok. & Schoenberger, 2017).

Moreover, the importation of plastic packaging products and other unnecessary plastic toy products need to be restricted and monitored.

Importation controls on plastic packaging products and other plastic items also fall within the purview of trade and environmental regulations. Countries may impose import restrictions or standards on packaging materials to reduce environmental impact and promote domestic recycling industries.

In conclusion, the legal analysis of zero waste strategies involves a complex interplay of environmental, consumer protection, trade, and waste management laws. Implementing and promoting zero waste practices require a holistic approach that addresses regulatory gaps, incentivizes sustainable production, and fosters innovation in waste management technologies.

4. ANALYSIS

Despite their differences, Germany and Sri Lanka share several similarities, particularly during the 1980s when Germany grappled with waste management challenges like insufficient landfill capacities and excessive use of beverage packaging. However, these two nations also exhibit notable differences in various aspects.

German jurisdiction in packaging waste plays a significant role in increasing the recycling of plastic waste, more over the collection, and separation (Balachandra & Abeysekara, 2021). However German system is an expensive method as its sole concern goes for recycling targets which hinder focus on the national market economy. Therefore, the desired goal is to implement the Green dot labelling system with due respect to the national market economy in Sri Lanka.

Hence, these German experiences can be extracted to fulfill the lacuna that exist in the context of domestic jurisdiction by implementing national laws on waste management upholding producers' responsibility over the plastic packaging waste in Sri Lanka.

Packaging is necessary for society to transport, protect, store and market products. (Boz, Korhonen, & Koelsch Sand, 2020) Therefore, Government policy should encourage innovation in packaging designs and uses before implementing regulation targeting on the manufacturers.

DSD created and maintained an infrastructure for the collection and sorting of materials. Collection bins were placed in convenient locations to allow consumers to dispose of packaging materials.

DSD then contracts with companies to handle the recovery and the delivery of these materials to sorting plants. Recyclers are paid by DSD to take the sorted materials. Companies, who wish to participate in the DSD program, thereby complying with the German statutory take-back requirement without the necessity of creating their system, must apply for permission to use a "green spot" symbol on their packaging materials. A product bearing the green spot is guaranteed to be composed of recyclable packaging (Ramasubramanian et al , 2023).

For a fee, DSD licenses the use of this symbol to companies whose materials DSD is willing to accept. Consumers and retailers may dispose of sales packaging bearing the green spot in DSD collection bins. Packaging not bearing this symbol cannot be disposed of in DSD bins and cannot be landfilled. The practical result is that retailers, who do not want to have to send materials back to their suppliers, even if the supplier pays for any expenses, insist on using the symbol (Ferreira et al, 2017)

The researcher identifies that compliance with the producer's responsibility in legislative framework and by implementation of Green dot system would contribute to the prevention of waste overflow in landfilling in Sri Lanka. Therefore, it is vital to implement regulations to maximize the recycling and recovery of plastic packaging waste and to minimize the impact of packaging waste on the environment in Sri Lanka. Product labelling system is a system which

would allow consumers to choose products with more sustainable features and materials (Preston, 2012).

Most of the consumers in Sri Lanka are not aware of the recyclability and biodegradability of the plastic packaging waste which negatively impact on separating the plastic packaging waste and finally hinders recycling and recovery of plastic packaging in Sri Lanka. Lack of information on plastic packaging has misguided the consumers and finally ended up not separating the waste precisely.

Regulation on material efficiency of product packaging is vital to force manufacturers to use recycling-friendly plastic materials for their plastic packaging. The green dot system adopted in compliance with a waste ordinance in Germany is an effective and efficient system to increase the plastic packaging waste recovery, recycling, and a proper plastic packaging waste disposal system in the market.

5. RECOMMENDATIONS

It is recommended to implement regulations on the manufacturers for mandatory labelling for reporting of quantities on the plastic packaging together with the plastic packaging material therefore making consumers aware of the recyclability, recovery of the plastic packaging waste.

Further, it is recommended to have an eco-labelling in Sri Lanka for take-back packaging by the producer for the increase of sustainable consumption through a legal framework for the procurement of eco-friendly products.

Legislation on plastic packaging will be vital for effective and efficient separation of plastic waste and an increase in recycling and recovery of plastic packaging waste and therefore to reduce mismanaged plastic waste and plastic pollution.

The regulation on plastic packaging will increase on sustainable consumption. This will increase the investable will be able. This will have an impact on the increase of the legal writing on the will inevitably increase on the packaging.

This will inevitably direct private consumers to do the right thing, whether at home or at work; rewarding good behaviours. Implementing regulations is as vital as introducing the alternative option for the consumers and also for the manufacturers.

6. CONCLUSION

The dual system in Germany requires examination of its impact on waste reduction, packaging usage, and the technological innovation and development of recycling. This system is concerned with reducing the volume of packaging introduced in Germany. Waste management in Germany has been characterized by effective development in the last 40 years. The German packaging ordinance uses the principle of recovering value from end-of-life and it is concerned about the producer's liability over the plastic packaging. Waste management regulations in Sri Lanka have not prioritized the increase of recycling or recovery of plastic packaging waste. Therefore, inadequate regulations on producer liability on plastic packaging hinder the preventive impact of unnecessary land consumption for landfilling in Sri Lanka.

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REMOTE LEARNING IN MILITARY HIGHER EDUCATION DURING COVID-19: CHALLENGES AND STRATEGIES FOR STUDENT OFFICERS IN SRI LANKA

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ABSTRACT

The COVID-19 pandemic precipitated a global shift in higher education toward remote learning, prompting diverse adaptations to ensure continuity in student education. This transition was particularly impactful in Sri Lanka, where the tri-forces' student officers, crucial for national defense, underwent remote postgraduate studies. This study investigates the challenges, perceptions, and proposed strategies of these officers pursuing the PSC (Master's degree at Defence Services Command and Staff College) during the pandemic. Grounded in Anderson's Theory and Practice of Online Learning, the research employed a descriptive cross-sectional design, surveying 30 male student officers via an online questionnaire. Results indicate a generally positive reception of remote learning, with 61.9% expressing satisfaction, despite encountering technical barriers, limited peer interaction, motivation issues, and content comprehension difficulties. While 52.4% reported moderate engagement levels, 66.7% acknowledged satisfactory lecturer support. The study suggests enhancing infrastructure, fostering interactive learning environments, and improving teacher-student interaction to mitigate challenges and bolster remote learning effectiveness. Notably, 85.7% of respondents advocate for hybrid learning, blending online and traditional methods. However, limitations include a small, male-only sample, limiting generalizability, and neglecting perspectives of officers with lower IT and English proficiency. Recommendations include policy interventions to enhance teacher-student interaction, promote engagement, and optimize remote learning quality, recognizing its pivotal role in future higher education. This study contributes insights into the challenges and prospects of remote learning in a unique military educational context, informing strategies for its effective implementation amidst crises and beyond.

KEYWORDS: *Remote learning, Higher education, Tri-forces, COVID-19 pandemic, Student officers*

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1. INTRODUCTION

The COVID-19 pandemic has been the biggest challenge across the higher education sector all over the world. It has impacted globally by the disruption of normal functioning (He et al., 2020). Therefore, governments implemented policies and regulations to maintain separation between communities, leading many countries to discontinue the traditional face-to-face teaching method (Hoofman and Secord, 2021). Further, the World Health Organization recommended the maintenance of social separation as an effective means of preventing the spread of COVID-19 (He et al., 2020).

The outbreak of the pandemic has led to the transition of remote learning, making it necessary to shift away from the traditional mode of face-to face learning to novel modes of education. This has paved the way for the utilization of wide range of technical sources ranging from lower tech options like the printed material, television, radio, up to highly developed technical sources like online learning platforms, to facilitate the continuation of learning. The process of adopting to remote learning during the pandemic was a momentary approach taken to face the challenging circumstances, and it was different from the well-designed approach of online learning (Wambaria, 2023). This massive transition has impacted multiple facets of education including the education provided for the tri-forces. Therefore, it was obvious that the military education underwent significant changes with its adaptation for remote learning. This has created the need to improve the mechanisms of remote learning with regards to the military education, specially to meet any similar challenges in the future.(Hodgetts et al., 2020). Moreover, it is important to note the vital role played by the tri-forces in enhancing the service provided by the public health systems during the outbreak of the pandemic (Gad et al., 2021).

During the COVID-19 period, the government of Sri Lanka decided to continue education online to ensure the uninterrupted progression of students' academic activities while adhering to health and safety protocols necessitated by the pandemic (Rameez et al., 2020). Consequently, many students pursuing diplomas and degrees transitioned to online learning (Sudusinghe and Kumara, 2020). Accordingly, the landscape of the higher education sector in Sri Lanka has undergone a massive transformation. This new change has also influenced the higher education of the officers from the tri-forces who require more adaptable and approachable learning environments. The tri-forces of Sri Lanka comprise of the army, navy, and air force. The officers from the tri-forces, who are committed to safeguarding and maintaining the integrity of Sri Lanka, constantly engage in their higher education as a vital component of their career development.

Even though numerous studies had been conducted globally concerning students' perceptions of remote learning, there had been a dearth of studies conducted in Sri Lanka as well as globally in assessing the challenges faced by student officers in the Tri-forces in pursuing their higher studies via remote learning. Moreover, military officers have to maintain a proper balance between their academic prospects and their designated military responsibilities. In this regard, remote learning became a more appropriate and flexible means of pursuing higher education. Assessing the perceptions of tri-forces officers regarding their experience with remote learning was crucial for informing effective strategies, policy-making, and overcoming challenges. Therefore, the current study was conducted to assess the perceptions, challenges, and proposed strategies of student officers from the Tri forces undertaking the PSC (Master's degree at Defence Services Command and Staff College) regarding remote learning during the COVID-19 pandemic.

Theoretical Framework

The current study is based on the Theory and Practice of Online Learning (Anderson, 2008), which has the potential to emphasize the importance of technology, learner autonomy and interaction in enabling effective online education. The theoretical

framework suggested by Anderson offers valued insights into the subtleties in the settings of remote learning and the aspects manipulating student satisfaction and engagement. Most importantly, it brings to light the value of facilitating interaction and catering to the challenges originated by technology to enhance the remote learning experience.

Literature Review

During the COVID-19 pandemic, remote learning has played a vital role in the field of higher education. This has given birth to numerous studies which aim to explore multiple aspects of remote learning including its challenges and opportunities. The Theory and Practice of Online Learning (Anderson, 2008) provides valuable insights to investigate these studies, highlighting the importance of interaction and technology in enabling effective online education. Accordingly, it was identified through the previous research that the encounters interrelated to student interaction and a decreased sense of belonging, which are central to Anderson's theory.

Numerous studies have attempted to explore the perceptions and challenges faced by students in the process of adapting to remote learning, especially with regards to the post-graduate students. Zamora et al., (2023) emphasized on the impact created by disrupted student interactions and decreased sense of belonging due to the transition into the remote learning environment. Martinez et al., (2023) highlighted the stressors associated with COVID-19, which impacted the graduate students. The main concerns were challenges associated with interfering academic responsibilities, leading to food insecurity and depressive symptoms. Parker et al., (2021) investigated on the perceptions of American students with regards to the forced transition to remote learning, exploring aspects like ethical behaviour and commitment during remote learning.

D'Souza et al., (2023) recognized that poor utilization of online tools and internet connections have created noteworthy challenges for nursing students during remote learning. Vintere et al., (2021) highlighted that factors such as motivation levels, teachers' e-learning knowledge, and the structured learning environment have the potential to impact on student satisfaction on remote learning. Nguyen et al., (2021) aimed to comprehend the students' understandings and perceptions on remote learning methods to inform future pedagogical decisions. Toquero, (2020) highlighted on the value of innovative approaches and the transition to emergency remote education during the pandemic.

Chaves, (2021) emphasized on the willingness and challenges of tertiary state university management students in remote learning, while providing recommendations on pedagogical and technological involvements to improve the online teaching-learning procedures. AlMunifi & Alfawzan, (2023) attempted to address the students' apprehensions and preferences with regards to remote, in-person, or hybrid learning experiences. Nash, (2021) highlighted on the significance of improving supervision and mentoring during the course of remote learning to decrease the stress and anxiety experienced by the students. In the military context, (Alnaqbi and Yassin, 2021) aimed to assess and investigate the encounters and approaches of inculcating artificial intelligence and e-learning in the UAE military education system, pointing towards the developing nature of educational practices in military settings.

Research Questions:

1. What are the key challenges faced by student officers from the Sri Lankan tri-forces in adapting to remote learning during the COVID-19 pandemic?
2. How do student officers from the Sri Lankan tri-forces perceive the level of interaction and engagement during remote learning, and what factors influence these perceptions?
3. What strategies can be proposed to mitigate the challenges faced by student officers from the Sri Lankan tri-forces in pursuing

their higher studies via remote learning during the COVID-19 pandemic?

2. METHODOLOGY

The current study was conducted as a descriptive cross-sectional study. The study sample comprised student officers from the tri-forces selected to follow the PSC. At the baseline level, 100 student officers were interviewed, and out of them, 30 male student officers who pursued their post-graduate studies via remote learning during the COVID-19 pandemic were included for the study.

Before the data collection, informed consent was obtained from the participants of the study. An online questionnaire developed by the investigators in English was circulated via WhatsApp among the selected student officers for a period of one week. The questionnaire comprised both open-ended and close-ended questions addressing their perceptions of the challenges experienced while engaged in their higher education via remote learning. Additionally, the questionnaire included questions to assess their proposed strategies to mitigate those challenges. The questionnaire was piloted among ten student officers attending the psc course to ensure clarity, relevance, and comprehensibility of the questions. Subsequently, those officers who participated in the pilot test were excluded from the final data collection to prevent any bias or influence on their responses during the main study.

Descriptive statistics were analyzed using SPSS 23.0 as per the study objectives. For the qualitative data, a rigorous thematic analysis was conducted. Themes were identified through a comprehensive process, involving multiple coders to ensure consistency and mitigate bias.

3. RESULTS

Level of satisfaction in remote learning

When assessing students' satisfaction with remote learning, the majority of the study sample (61.9%) reported being satisfied with their experience and 38.1% have reported to be fairly satisfied with learning online.

Respondent three mentioned remote learning as a "highly accessible and convenient means of doing post graduate studies". In addition, respondents eight and eleven have mentioned remote learning to be a "very flexible mode of learning that caters to the needs of the individual". It reveals that remote learning has a strength of being user-friendly due to its high degree of accessibility and flexibility. Some have responded positively about their experience of remote learning.

Main challenges faced during remote learning

As per the findings of the study, there are key challenges identified by the study sample namely, technical barriers, limited interaction with peers, lack of motivation and difficulties in understanding the course content. Nearly 50% of the study sample identified technical difficulties as the dominant challenge. In addition, 20% have revealed limited interaction with peers as a challenge for the success of online education. Similarly, 20% have mentioned lack of motivation as a key challenge that they came across.

Respondents one and six have mentioned that they key problems with regard to the technical barriers were "connectivity issues and the usability of the platforms". Respondent nine has indicated that "limited engagement with peers is a barrier to the overall success of remote learning".

The level of interaction and engagement

When considering class interaction and engagement, 52.4% have shown a moderate level and 33.3% have had a low level of interaction and engagement during e-learning. Moreover, only 14.3% are highly engaged with the lessons during distance learning.

Respondent number seven has revealed that "I feel that many students are reluctant to express their ideas and interact in online classes compared to their

presence in actual classroom". Similarly, respondent number twelve mentioned that "According to my opinion, the weak students get severely affected by remote learning due to lack of interaction".

Support Received by the Lecturer During E-Learning

The support and guidance given by the lecturers play a key role in enhancing the students' experience concerning remote learning. It will enable them to potentially tackle the challenges they come across. According to the results, 66.7% of students have received assistance and guidance from their lecturers at a satisfactory level during e-learning, while 5% have received lecturer assistance at a highly satisfactory level. Further, 28.6% of students have remained neutral in terms of their responses.

Respondent number four has mentioned that, "I am very happy about the support given by the lecturers". However, respondent number fourteen said that, "lecturers find it difficult to give individual attention when it is an online class". Moreover, respondent number twenty-three mentioned that "lecturers did their best to make the virtual classroom very student friendly".

Participation in Discussions and Activities in the online classroom

As per the findings of the study, the majority of the students 61.9% have taken part in discussions and activities done in online classrooms. Respondent number ten mentioned that, "I really enjoyed taking part in the online activities done in zoom classes". Similarly, respondent number seventeen mentioned that "I took part in all the discussions done via virtual classes and I found it interesting".

Overall Experience with E-Learning

Regarding the overall experience of remote learning, 57.1% responded positively. Moreover, 28.6% have remained neutral and 14.3% have identified it as a negative experience.

Respondent number twenty-two has mentioned: "For me, online education was a whole new experience and I enjoyed it a lot". In the same way, respondent number thirty indicated that virtual learning was very easy and comfortable for him than attending classes physically. However, respondent number seventeen mentioned that he preferred on site classrooms to virtual classes as it promotes more student interaction.

Future learning preferences

The results show that 85.7% of the respondents prefer continuing hybrid learning, incorporating both online and traditional methods, and 9.1 % have not preferred to continue their studies in both methods.

Respondent number six mentioned: "I prefer hybrid mode as there are some modules which really need onsite lecturing and others can easily be managed virtually". Moreover, respondent number twenty-five has mentioned that "adapting to the hybrid mode of learning is very cost effective in the modern context". However, respondent number nine has revealed that, "hybrid mode of learning will not benefit all the students equally and it will have many disadvantages". Hence, the majority of the population has preferred to continue learning by using both methods.

4. DISCUSSION

The current study aims to assess the perceptions of selected student officers from the tri-forces who have been selected to follow the PSC regarding their perceptions on the challenges of remote learning consistent with the Theory and Practice of Online Learning (Anderson, 2008). The selected officers have pursued their higher education via online mode during the Covid-19 pandemic. As per the study findings, for majority of the participants it was their first-time experience with regard to the remote learning. Despite being their first experience in remote learning, the majority of the study sample have responded positively regarding their satisfaction and effectiveness of online education. A similar study conducted by Sudusinghe and Gamage (2020) to

assess the experience of remote learning among a group of Sri Lankan university students revealed that the majority of the students were neutral in terms of their perceptions regarding the effectiveness of remote learning. Another study conducted in Turkey of the same context also revealed that majority of the students remained neutral regarding the effectiveness of online education (Altunay, 2019).

Furthermore, as indicated by the study findings of Sudusinghe and Gamage (2020), the majority of the students disagreed with the statement that on site education is better than remote learning. The findings of the current study revealed that majority of students have expressed a preference for continuing hybrid learning, incorporating both online and traditional methods. This indicates that they prefer the hybrid learning method due to high degree of flexibility and accessibility.

Moreover, there are key challenges identified by the study sample namely: technical barriers, limited interaction with peers, lack of motivation and difficulties in understanding the course content. The technical barriers were identified as the most prevalent challenge among the key challenges. Therefore, it has been revealed that the above challenges have disrupted the success and the effectiveness of remote learning. Furthermore, in terms of interaction and engagement via distance learning, it has been observed that a satisfactory level has not yet been achieved by a reasonable percentage. Hence, it is clear that there is a need to incorporate more interactive activities into online teaching to make it more effective and fruitful.

Another study has revealed that the utilization of a user-friendly interactive platform has facilitated the participation in discussions and engagement of both students and lecturers. Furthermore, it has been revealed that the provision of recorded lectures, reading materials, and interactive simulations can help mitigate difficulties that have arisen during the learning process (Mahmood, 2021). Moreover, another study conducted in Indonesia has mentioned that ensuring access for both parties, such as lecturers and students, to reliable technology and technical support has mitigated the difficulties that arise during online learning (Utomo et al., 2021).

The support given by lecturers and their guidance play a key role in enhancing students experience with regard to remote learning. It will enable them to potentially tackle the challenges they come across. According to the results, majority of students have received assistance and guidance from their lecturers at a satisfactory level during e-learning. Further, a study carried out in Thailand among the students following an English course via remote learning has revealed that weak students would be disadvantaged by distance learning and they need self-directing guidance through a tutor (Altunay and Mutlu, 2010). This indicates that the lecturers' assistance plays a key role in the success of remote learning.

Limitations

It will be difficult to generalize the findings of the study to the general population since the study sample comprises of only 30 student officers who have been selected to follow their post graduate studies. Additionally, the study sample comprises only male officers and no perceptions of female officers have been considered. Further, the student officers who have been selected for the course were competent with their IT knowledge and English Language proficiency. Therefore, an assessment of the challenges encountered by the students with poor IT and English language proficiency was not be possible with the current data.

5. CONCLUSION AND RECOMMENDATION

The current study has presented challenges encountered by the student officers in the tri-forces engaged in remote learning during the Covid-19 pandemic. It was also clear that the majority of the participants were satisfied with their experience of remote learning. However, there are key challenges identified by the study sample namely; technical barriers, limited interaction with peers, lack of motivation and difficulties in understanding the

course content. Among these challenges, technical barriers were identified as the most dominant. Hence, it is clear that improving the infrastructure would facilitate successful delivery of remote learning. Further, it was also highlighted that there need to be more activities catering to the student engagement and interactive learning. It would make the learning experience more productive and keep the student motivation at a satisfactory level.

Moreover, it was revealed that the support and guidance given by lecturers play a key role in enhancing the students' experience with remote learning. It will enable them to potentially tackle the challenges encountered by them. According to the results, the majority of students have received assistance and guidance from their lecturers at a satisfactory level during e-learning. Hence, it is recommended to implement policies and strategies to enhance the student-teacher interaction in remote learning. Additionally, it is also recommended to improve the level of engagement of students in discussions and interactive activities during online classes. It would benefit the students by enhancing their level of confidence and motivation.

With the results of the study, it has become evident that the majority of students have expressed a preference for continuing hybrid learning, incorporating both online and traditional methods. Therefore, it is clear that remote learning carries its own set of advantages and disadvantages. As a result, it is recommended to enhance the delivery of remote learning by overcoming its potential disadvantages. It is also clear that remote learning will play a significant role in the higher education sector in the future. Hence, policy makers, the government and higher education institutes need to implement strategic measures to enhance the quality of remote learning in Sri-Lanka.

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FOSTERING LEARNER AUTONOMY AND BEST APPROACHES TO IMPLEMENT THE PRACTICE

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ABSTRACT

As per the definition, "The ability to take charge of one's own learning", Learner Autonomy (LA) has been a significant theme of interest in second and foreign language learning over the last five decades. Yet this concept is not widely practiced among local learners in the English as a Second Language (ESL) pedagogy. Implementing autonomous learning behaviours benefits the education system, of a country like Sri Lanka, to minimize most obstacles the ESL learners encounter. For a successful implementation of the concept, the contribution of both teachers and students is essential. Therefore, this research aims to identify sixty ESL teachers' understanding of how much they support in fostering LA, and the best approaches to implement the practice. Using the simple random sampling method, 10% out of 600 English teachers from the Galle zonal division were given a researcher-made questionnaire that included four sections. A 5-point Likert scale was used to measure the collected data, and they were quantitatively analyzed using descriptive statistics. The SPSS version 21 was used, while Cronbach's alpha determined the reliability of the Likert scale. The questions were composed of identifying the teachers' understanding upon the LA concept, the teachers' roles and responsibilities in planning, implementing, monitoring, and evaluating the class; and how the teachers view their learners' abilities to take responsibility in planning, implementing, monitoring, and assessing their learning tasks, while suggestions were forwarded to get the teachers' preferences as the best approaches to foster autonomy among ESL learners. Significantly, 98.3% believe that implementing LA is essential, and the study concluded with the understanding that teachers are willing to cultivate LA if a suitable environment is created.

KEYWORDS: *best approaches, fostering learner autonomy*

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1. INTRODUCTION

In the context of second or foreign language teaching and learning, it is essential to understand that language cannot be learned and taught only in the confines of a classroom or within a specific period. Language learning is a lifelong learning process. Language has several nuances, and language learners vary in their skill levels. Therefore, autonomy is essential for language learning and teaching. However, learners only become autonomous automatically if they are allowed to be autonomous in their learning experiences, which means the teacher has a significant role in this process. Most importantly, the teachers' roles as managers, organizers, facilitators, and counselors are prominent in fostering autonomy among ESL learners (Wintek Yan, 2012).

The hypothesis of the present study is that, the teachers' presence in the process of fostering autonomy among ESL learners is essential and having a better understanding and experience of it among the teachers is equally essential for a successful outcome from the learners.

As autonomous teaching and learning strategies are not widely practiced in the Sri Lankan ESL context, most ESL teachers express a gloomy picture towards this concept for several reasons. Moreover, there is a need for more empirical and in-depth studies on teacher autonomy, teachers' role in fostering autonomy, and their perspectives and attitudes on autonomous language teaching and learning in the Sri Lankan ESL context. Further, it indicates a significant gap of knowledge in being autonomous among local English teachers of all levels. The accessible studies also do not focus much on the teachers' role in fostering autonomy in the local context while the available limited literature are also mostly focused on autonomy upon the learners, for example: (Premawardhena et al., 2015) and (Prasangani & Nadarajan, 2015).

Overall, the respondents of the present study view their teaching practice as quite traditional and explained the barriers they encounter because of the expectations of the ministry, society, and institutes, teachers' own experiences, and mainly due to the existing education system that has been practiced so far. Some teachers disagree that they developed LA and showed a mixed attitude towards enhancing LA, while some are very positive towards it. Still, they accepted minimal chances of practicing it in real teaching-learning contexts. In general, the common practice among all the teachers was giving prominence to the textbook and the completion of the prescribed syllabus; while learning activities that enhance creativity, learner inquiry, providing freedom for learner choices in selecting lesson topics and learning methods, identifying goals, out of class activities and having an authentic language learning environment are far from the practice.

Considering the definition of learner autonomy introduced by Henry Holec (1981), "the ability to take charge of one's learning," most teachers and learners bear the misunderstanding that there is no place for a teacher in this process, that the students are all alone and have to continue their studies as they wish. But in reality, the bond between teacher and learner is inseparable as the two sides of a coin. The teacher's guidance and scaffolding and an autonomous-friendly learning environment are essential for a student to become an autonomous learner (Genç, 2015).

According to the guidelines introduced by (Benson, 2007), to foster autonomy, teachers must be actively involved in students' learning, provide options and resources, offer choices and decision-making opportunities, support learners, and encourage reflection.

According to Reeve et al. (1999) in (Stefanou et al., 2004), the researchers have categorized teachers as high or low in autonomy-supportive. Alongside this, (Borg & Al-Busaidi, 2012) also suggest some guidelines for high autonomy-supportive teachers as follows: encouraging students to go the extra mile and not to be afraid of making mistakes, finding out specific topics and being ready to discuss in the next classroom session, negotiating deadlines, issues for homework, talking to the learners regularly on why and what they do in the class in a bigger picture, telling learners that knowledge is available everywhere and what is needed is the method to find and make them

use, and encouraging peer assessments at the classroom level. Further to (Han, 2014), the teachers' instructions to learners on awareness, involvement, intervention, creation, and transcendence are also important. However, due to the existing practices in most language teaching and learning environments, fostering autonomous practices has become a significant challenge to most teachers. As pointed out by (Yunus & Arshad, 2015), "the 'spoon feeding' system has left negative effects upon the learners' learning styles, and preferences which result in the lack of self-confidence among students since their knowledge is solely based on theories that they cannot apply them in their daily lives. As learners cling to their teachers, the learners themselves limit their ability of independent and critical thinking power, resulting in poor creativity skills that hinder their true potential and confidence."

Moreover, autonomous language teaching and learning practices are yet to be extensively practiced in the Sri Lankan context. Since gaining English language proficiency is still far from easy for most local learners, according to the studies by Fonseka (1996) and Fonseka (2003), there are several advantages of employing LA strategies in the local ESL pedagogy. Therefore, the objectives of this research are to explore the role of the language teacher in the classroom, the level of autonomy exercised by the teachers, whether they fostered learner autonomy through their teaching practices, examine language teachers' concept of autonomy, and interactions and processes that took place in their classrooms which might or might not have fostered autonomy and the teachers' perspectives on the concept. Thus, the research questions of the study are as follows:

1. What is the perspective of English language teachers in fostering autonomy among language learners?

2. What are the strategies and supportive characteristics used by teachers in enhancing autonomy among learners?

Moreover, the present study is influenced by the theories of Constructivism, Personal Constructed Theory, Self- Determination Theory (SDT), and the theory of Mediation.

METHODOLOGY

As same as giving importance to the learners' perspective in developing learner autonomy, the teachers' role should also be studied equally. Further, to enhance learner autonomy, a teacher may have to use several activities and teaching methods to help learners identify their goals and use effective strategies to achieve them. To fulfill this achievement, the teacher's understanding of the importance of the autonomy concept, their willingness to use autonomous teaching strategies, and firsthand experience are crucial (Aoki, 2003; S. Borg & Al-Busaidi, 2012; Mariani, 1997; N. Nguyen, 2014; Szőcs, 2017).

In the present research, a researcher prepared questionnaire (Appendix 1) was employed to explore teachers' perspectives, beliefs, strategies, and characteristics in enhancing learner autonomy; and followed the group distribution method for this survey. Group distribution is a method of collecting data in survey research in which the investigator distributes a survey to the participants face-to-face. In particular, for the current study, different schools within the Galle Zonal division were visited in person to distribute the questionnaires with the permission of the Ministry of Education, the Galle Zonal Education office, and the school's administrative staff. Both the researcher and the participants preferred using hard copies of the questionnaire due to convenience and the reliability of the return rate of the questionnaire. This study used simple random sampling. One of the reasons this technique is used is that the simple random sample means that every case of the population has an equal probability of inclusion in the model. The sampling technique of the present study was a group of 60 teachers, 10% of the population of 600 English teachers, who conduct English lessons for the grade 8 students in the schools of the Galle zonal division. Further, these schools follow the same government syllabus, and the selected schools represent both national and provincial schools in the Galle zone. These schools are demographically located in both urban and rural areas within the zone. This study had a sample size of sixty teachers to facilitate the quantitative analysis of data from the questionnaire.

The educational qualification of the sample group varied from Advanced Level (A/L) to Master's degree (M.A.), while the years of teaching experience ranged from 1 to 35 years. This sample is also significant due to its representation of the school categories as National schools and provincial schools; and upon the popularity categorization of the schools as A- type, B- type and C- type. The reliability (internal consistency) of the Likert scale of the survey and its subscales were calculated using SPSS scale reliability analysis. The coefficients for the two survey subscales – Fostering Autonomy (α = .69) and Best Approaches to Foster Autonomy (α = .78). Considering the reliability of the questionnaire, a pilot study was conducted in three steps. Firstly, the questionnaire was given to five senior English teachers (they were not from the sample group). Secondly, it was distributed among five teachers from the sample group, and their filled questionnaires were also included in the analysis. And thirdly, the reliability was also determined by Cronbach's alpha using SPSS. To ensure validity, every questionnaire was cross checked by the researcher to ascertain its completion and instructions followed.

The questionnaire was divided into four sections. Firstly, it examined the teachers' understanding of the concept of LA and to what extent they think it is essential for learners. Secondly, the teachers' responses were gathered on the teachers' understanding and familiarity with possible strategies to foster autonomy among the learners. Thirdly, the teachers' preference for the suitability of the prescribed methods to implement autonomous learning practices was discussed. Fourthly, the data were gathered on the best approaches to foster learner autonomy.

2. RESULTS

Teachers can encourage autonomy through their teaching practices only if they clearly understand the concept of autonomy and are autonomous themselves. To be pro-autonomous teachers, they should be reflective and innovative in their teaching (Choudhury, 2015).

In the first section of the survey, teachers were questioned about their awareness of learner autonomy and attitude and their first-hand experience with learner autonomy.

Table 1 Definitions of the term 'Learner autonomy'

	Learner autonomy is defined as:	Frequency	Percentage (%)
1	A capacity that teachers can help learners develop in the learning process.	24	40
2	The situation in which learners are responsible for their learning.	20	33.3
3	Leaner's right to take control of their own learning.	5	25
4	The same as self-study (self-instruction)	1	1.7
5	Teachers are fully withdrawn from the teaching and learning process.	0	0
6	Others	0	0

Table 2: Teachers' beliefs regarding the importance of autonomous learning

	Is implementing learner autonomy important?	Frequency	Percentage (%)
1	Yes	59	98.3
2	No	01	1.7

Firstly, Table 1 summarizes the responses with high and low perceptions among the teacher respondents regarding their understanding of learner autonomy. More respondents (40%) in the high group thought of learner autonomy as a capacity for teachers to help learners develop in the learning process. However, there were more participants in the second group who believed learner autonomy was the situation in which learners are responsible for their learning, which is 33.3%.

Thus, it is notable that only 25% of respondents believe that learner autonomy means the learner's right to take

control of their learning. However, 1.7% also believe it is a method of self-study.

Taken together, these results suggest that the teachers' understanding of learner autonomy and the role of teachers in fostering autonomous learners is somewhat conflicted. Therefore, it is evident that additional in-service professional development may well be needed.

Secondly, the above-mentioned table (table 2) displays the percentage and frequency of teachers' beliefs regarding the importance of autonomous learning. Accordingly, the majority believes that implementing autonomy is essential.

Thirdly, the analysis of data gathered on the strategies used by the teachers to foster autonomy is as follows. More than 50% of teachers believed discussing the LA strategies with the students was essential. Still, it is a bit unclear regarding the teachers' practices and procedures to implement the task. The following aspects are related to the activities the teachers can arrange to give autonomous learning exposure inside the classroom. But a high proportion of teachers, more than 50% in almost every item, held negative or undecided views concerning implementing autonomous practices. Notably, most respondents support encouraging learner-centered activities, self-study practice, group work, and using authentic materials outside the classroom. But on the contrary, a considerable percentage of teachers do not support the rules such as deciding the objectives of the lessons, choosing learning activities, self-evaluations, deciding the seating arrangements, and deciding on homework. The foundation of the particular results suggests a conflict among teachers' understanding of what is required to develop more autonomous behaviours among the learners. Further, there is a vivid contradiction between what they believe independent learning is and their role as teachers. However, it is noteworthy that many teachers hold positive beliefs about approaches to fostering learner autonomy. Concerning the first item of Table 3, approximately 62% (53.3% A & 8.3% SA) indicate agreement in discussing learner autonomy strategies with the learners. But only a few favour (Agreeing) the idea of allowing deciding the lesson's objectives; that is 13.3%. Further, enabling the learners to select learning activities is also favoured by a smaller number of 25% (21.7% A & 3.3% SA). Evaluating the study outcomes was also preferred by a less number, around 28% (26.7% A & 1.7% SA). Also, it is essential to note that 65% (33.3% D & 31.7% U), a considerable number, disagree and are uncertain about this idea. On

Table 3 Fostering Autonomy approaches

		SD %	D%	U%	A%	SA %
1	Discussing learner autonomy strategies in the lessons with the students is essential	**0**	28.3	10	53.3	08.3
2	My students can decide the objectives for each lesson	0	63	23.3	13.3	0
3	My students can select their learning activities for each lesson.	5	51	18.3	21.7	3.3
4	My students can evaluate the study outcomes of each lesson.	6.7	33.3	31.7	26.7	71.7
5	I encourage learner-centered learning activities as much as possible.	0	3.3	1.7	66.7	28.3
6	I let the learners decide their seating, and classroom arrangements.	5	50	13.3	28.3	3.3
7	I give the learners the freedom to decide on their homework	5	68.3	6.7	20	0
8	I encourage self-study	0	0	0	60	40
9	Encouraging group work	0	0	0	58.3	41.7
10	Encouraging learners to use authentic materials outside the classroom.	0	1.7	1.7	58.3	41
	Overall approaches of fostering autonomy	2.1	30	11	41	16

32.1 % Negative, 57.4% Positive N = 60,

(SD: Strongly Disagree, D: Disagree, U: Undecided, A: Agree, SA: Strongly Agree)

the other hand, the highest percentage of 95% (66.7% A & 28.3% SA) teachers mentioned that they encourage learner-centred learning activities as much as possible. Again, giving the opposite idea, 32% (28.3% A & 3.3% SA) of teachers agree to allow the learners to decide their seating and classroom arrangements, and only 20% have the freedom to determine their homework. But once again, all the teachers 100% mentioned that they encourage self-studies and group work; more than 97% (58.3% A & 38.3% SA) stated they enable the learners to use authentic materials outside the classroom.

Overall, there is a vivid contradiction between what the teachers believe and encourage and their understanding and attitudes toward autonomous learning. For example, the teachers do not agree with the learners' fundamental concepts and practices of autonomous behaviour, such as deciding lesson objectives, choosing learning activities, etc. But the teachers only encourage the activities like group work and self-study activities. Therefore, it is questionable whether there is a possibility for fundamental autonomous practices in a learning environment of this kind.

Finally, the analysis was based on data on the best possible approaches to foster autonomy among the learners. Table 4 shows the teachers' beliefs about the six listed methods regarding the best practices to foster learner autonomy. Concerning the first item, providing students with learning materials and resources would promote learner autonomy; approximately 92% of teachers indicated agreement (78.3% A & 13.3% SA). Similarly, about 92% of teachers agreed (76.7% SA & 15% SA) that applying ICT to language learning helped to foster learner autonomy; about 93% (66.7% A & 26.7% SA) agreed that training students to develop their skills and strategies would allow students to become autonomous; approximately 98% (73.3% A & 25% SA) indicated that there must be curriculum reform to enhance learner autonomy; about 98% (51.7% A & 46.7% SA) agreed that practical learning would assist in developing learner autonomy; and finally, 100% (71.7% A & 28.3% SA) teachers expressed their agreement that further training for them will help students gain greater autonomy.

Table 4 The best approaches to fostering learner autonomy

		SD%	D%	U%	A%	SA%
1	Providing students with learning aids	0	3.3	5	78.3	13.3
2	Applying ICT skills and knowledge to language learning.	1.7	3.3	3.3	76.7	15
3	Training students to enhance and apply their skills on Learner-independent characteristics and strategies to become autonomous	0	1.7	3.3	66.7	26.7
4	Curriculum improvements.	0	0	1.7	73.3	25
5	Encourage more practical learning activities.	0	0	1.7	51.7	46.7
6	Training teachers.	0	0	0	71.7	28.3
Overall best approaches to fostering learner autonomy		0.2	1.3	2.5	70	26
1.5 negative, 96% positive						
N=60 (SD: Strongly Disagree, D: Disagree, U: Undecided, A: Agree, SA: Strongly Agree)						

Table 5 Teachers' Overall Understanding of Learner Autonomy

		SD%	D%	U%	A%	SA%
1	Teachers' Beliefs about Responsibility	2.1	15.4	6.7	54.7	21.1
		17.5% Negative			**75.8% Positive**	
2	Fostering Autonomy	2.1	29.9	10.9	40.6	16.5
		32% Negative			**57.1% Positive**	
3	The best approaches to fostering learner autonomy	0.5	1.6	2.4	69.7	25.8
		2.1% Negative			**95.5% Positive**	

The Table 5 represents the data on Teachers' Overall Understanding of Learner Autonomy in Language Learning. These values of the overall data were gathered from the main four subsections of the distributed questionnaire. In the first place, in talking about the responsibility of the students' learning process, a high proportion of teachers (75.8%) believe that they have an overall obligation in all the aspects of students' learning process. Next, the teachers' responses on the second subscale show that teachers are very much in agreement (57.1% positive) that specific autonomous-friendly practices can foster autonomous behaviour in their learning contexts. Further, this finding suggests that, even though the teachers may have explicit conflicts in their understanding of learner autonomy, they strongly agree that particular approaches and strategies might be practical to foster autonomy among language learners. Further, it is noteworthy that a considerable number of 32% of respondents oppose this idea.

Thus, another 10.9% of respondents are uncertain about this process. Finally, talking about the best approaches to foster learner autonomy, teachers agree (95.5% positive) that the actions mentioned in the survey sheet can encourage autonomous practices in Their teaching and learning context.

However, considering teachers' sense of responsibility, behaviour, and understanding, the data indicated that they do not have a thorough awareness of learner autonomy and its significance in that process.

Moreover, it is essential to note that teachers held different interpretations of learner autonomy. Further many teachers have conflicting views regarding learner autonomy. Finally, in the third section of the distributed questionnaire, the data indicate that the teachers agree that specific improvements and amendments to the existing ESL teaching and learning practices can enhance autonomous learning in their contexts.

Focusing on testing the hypothesis by analyzing the data, it is identified that the teachers are positive towards fostering autonomy from the aspects of beliefs and responsibilities, implementing LA and best approaches.

3. FINDINGS

It is significant to note that, before implementing LA among students, teachers must have an understanding and familiarity towards the concept and its practical implications. However, according to the findings, it was understood that, the teachers' do not have awareness of learner autonomy and its significance. In that process there are gaps in the sense of responsibility, behaviour, constraints, and understanding as indicated in the data.

Moreover, it is essential to note that teachers held different interpretations of learner autonomy. Many teachers have conflicting views regarding learner autonomy. The reported data clearly shows the teacher's low awareness of the concept of learner autonomy. Regarding the sharing of responsibilities in the class, the results suggest that teachers do not hold a stable opinion that they believe they have a high obligation in the process of students' learning. Still, they say they share the authority and are not responsible for the whole process. Further, it shows that the teachers take a significant role in the existing education system, and the learners share a lower proportion. As reported above, the teachers' experience with the constraint to students developing greater autonomy for their learning, the data indicate that the teachers positively believe that there are constraints to foster learner autonomy practices in their educational contexts.

Finally, it was understood that the teachers agree that specific improvements and amendments to the existing ESL teaching and learning practices can enhance autonomous learning in their teaching context.

4. DISCUSSION

In the present study, it was identified that the participants need to understand the term Learner Autonomy (LA) clearly. Reversely, their confusion can also be due to the linguistic issue in translating learner

autonomy into Sinhala. However, the teacher sample being Sinhala native speakers, it is also essential to understand the native definition of the term 'learner autonomy' as "*igena gannange swadeenathwaya* - ඉගෙන ගන්නන්ගේ ස්වාධීනත්වය". However, this translated term is very general to understand as it needs to clearly and define what dimensions of learner autonomy are being focused on in the local educational setting. Therefore, the translation of the term may lead to different interpretations in various contexts. In Sinhala, the word "*swadeenathwaya-* ස්වාධීනත්වය" gives an idea that you do it on your own, by yourself or being independent. Moreover, the word '*Swayan-* ස්වයන්' also applies in Sinhala to the term independent learning as '*Swayan adhyaapanaya-* ස්වයන් අධ්‍යාපනය'. On the other hand, these two Sinhala terms suggest a learning situation where the teacher's role is absent, which drives a complete misinterpretation of the exact English definition of LA. Moreover, in the local teaching and learning context, there is no opportunity to practice an autonomous learning behaviour since the local education system itself is moving into a particular conventional education system, where researching, self-studying, and learner preferences are not very much encouraged.

However, the best person to encourage autonomy in students is an autonomous teacher, that is, one who understands the value of autonomy, has a positive attitude toward developing it, continuously evaluates students' progress, and supports students in becoming autonomous. According to the data of the study, the teachers also bear different definitions of the term learner autonomy. Consequently, 40% of teachers believe that LA means 'a capacity teacher can help learners to develop in the learning process.' In comparison, 33.3% believe it is the situation in which learners are responsible for their learning. Finally, only a minority of 25% believe that it is the learners' right to take control of their own knowledge. These percentages vividly indicate that these teachers do not have a proper understanding or familiarity with this concept and are not expected to practice it in reality. Yet it was prominent that the teacher was considered as a controller and knowledge provider in the class rather than the facilitator. Thus, it is also significant to note that almost all the teachers take control and responsibility in the classroom and that they do not like to share the responsibilities with the learners. But at the same time, the teachers express a nature of reluctance to take responsibility for the idea of 'authority,' which is very contrasting with their actual practice and understanding. The teachers in the current research had not trained on how to implement learner autonomy. They also have certain doubts about developing and implementing learner autonomy practices in their classrooms. Moreover, the teachers' belief that students were not competent enough to give valuable opinions about their learning was evident in the teachers' approach in the classroom, as they failed to involve their learners in any discussions regarding what they should do or why they should do a particular lesson.

6. CONCLUSION

Teaching and learning must be interconnected. Hence, the objective of language teaching and learning has to move away from the immediate goal of passing examinations and expand to an understanding that language learning is a continual process and requires more than just learning its grammar. Once that is clear to teachers and learners, the changes in how language is taught and known will be a natural progression.

Nevertheless, this study argues that most ESL teachers must understand learner autonomy in the selected study context. Through the responses, it was identified that the traditional relationship between teacher and students in the classroom, mainly expressed an authoritative role as well as a lack of learner autonomy in these teaching contexts. Perhaps due to the pressures and constraints felt because of the examination system and the inability to exercise their independence, teachers were frustrated by their teaching situation and started to believe that there was nothing they could do to change.

Finally, what is essential is that autonomy should result in learners becoming critical thinkers and life-long learners and teachers becoming professionals who are also critical thinkers and life-long learners. And yet, the teachers firmly believe that autonomous learning

practices are essential in ESL learning, and the teachers can create a supportive environment

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Appendix

Questionnaire

Section 1

Learner autonomy means:

(Please pick one of the answers below or write your answer.)

a. A capacity that teachers can help learners to develop in the learning process.
b. The situation in which learners are responsible for their learning.
c. Leaners ' right to take control of their own learning.
d. The same as self-study (self-instruction).
e. Teachers are fully withdrawn from the teaching and learning process.
f. Others

Is implementing Learner Autonomy important? NO YES

Have you experienced Autonomy as a learner? NO YES

Section 2: What are your responsibilities in your class?

(Please mark the corresponding answer, only one per line.)

	Strongly Disagree	**Disagree**	**Uncertain**	**Agree**	**Strongly Agree**
I am responsible for deciding the objectives for each lesson in my classroom.					
I am in-charge of selecting the learning content for each lesson.					
I am accountable in evaluating my students' learning progress in each lesson.					

	Strongly Disagree	**Disagree**	**Uncertain**	**Agree**	**Strongly Agree**
I am responsible for selecting the teaching methods and techniques to be used in each lesson.					
I am in-charge of monitoring the learning process in each lesson.					
I am responsible for the whole learning process of the learners.					
I should maintain authority in the classroom.					

Section 3: Are you an autonomy-supportive teacher?

(Please mark the corresponding answer, only one per line.)

	Strongly Disagree	**Disagree**	**Uncertain**	**Agree**	**Strongly Agree**
Discussing learner autonomy strategies in the lessons with the students is important.					
My students can decide the objectives for each lesson.					
My students can select their learning activities for each lesson.					
My students can evaluate the study outcomes of each lesson.					
I encourage learner-centered learning activities as much as possible.					
I let the learners decide their seating and classroom arrangements.					
I give the learners the freedom to decide their homework.					
I encourage self-study.					
Encouraging group work.					
Encouraging learners to use authentic materials outside the classroom.					

Section 4: Which is the best approach to foster learner autonomy in your educational context?

(Please mark the corresponding answer, only one per line.)

	Strongly Disagree	**Disagree**	**Uncertain**	**Agree**	**Strongly Agree**
Providing students with learning aids.					
Applying ICT skills and knowledge into language learning.					
Training students to enhance and apply their skills on learner independent characteristics and strategies to become autonomous.					
Curriculum improvements.					
Encourage more practical learning activities.					

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PROTECTION OF GEOGRAPHICAL INDICATIONS (GI) IN SRI LANKA: A CRITICAL LEGAL ANALYSIS

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ABSTRACT

Sri Lanka is renowned for its ownership of numerous esteemed Geographical Indications (GIs), a testament to its rich cultural heritage and diverse agricultural products. However, the proliferation of counterfeit indications and illicit practices poses a significant threat to the integrity and value of these GIs in the global marketplace. As the nation of origin, Sri Lanka bears a paramount responsibility to safeguard these GIs, both domestically and internationally, as mandated by the Intellectual Property Act and ratified treaties.

Against this backdrop, this research seeks to conduct a comparative evaluation of Sri Lanka's Intellectual Property Law regime, specifically focusing on the adequacy of legal provisions governing geographical indications in protecting existing GIs. Employing a qualitative research methodology, this study draws upon a comprehensive analysis of primary and secondary legal resources.

By juxtaposing the domestic legal framework with international standards and practices, this research endeavours to draw conclusions regarding the effectiveness of existing protection measures and proposes targeted reforms where necessary. The aim is to formulate tailored recommendations for enhancing Sri Lanka's GI regime through the worldwide exhaustive examination of geographical indication regimes.

This research paper not only contributes to academic discourse but also serves as a practical guide for policymakers and stakeholders involved in the preservation and promotion of Sri Lanka's unique GIs. Given the urgency of addressing the challenges faced by GIs in the contemporary global trade landscape, this study underscores the importance of timely action and informed decision-making in ensuring the continued prosperity of Sri Lanka's geographical indications.

KEYWORDS: *Geographical Indication, Intellectual Property, TRIPS, WIPO, WTO*

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1. INTRODUCTION

Geographical Indications (GIs) serve as crucial identifiers of a product's origin, embodying its unique qualities and cultural significance. In Sri Lanka, the legal framework governing GIs plays a pivotal role in protecting and promoting the country's diverse cultural heritage and agricultural products (Silva, 2015). This section examines the laws directly addressing GIs in Sri Lanka, beginning with the Intellectual Property Act. Winston Churchill's famous assertion about Champagne underscores the importance of product origin, sparking discussions on the intellectual property landscape. While intellectual property laws safeguard against unfair competition and false indications, the concept of Geographical Indication (GI) provides a verbatim answer to the question of a product's origin. GIs identify a product's geographical origin also by adding value by conveying its specialty, quality, and reputation but also as serving as a cultural emblem. GIs serve as a marketing tool and economic driver, gaining worldwide recognition over the past two decades, serving as both an intellectual right and a theme of industrial property protection (Askari, 2018). Isolated villages known for their GI products have become landmarks on world maps, emphasising the market-oriented role of GIs in achieving economic growth. Particularly in developing countries, GIs are intertwined with socio-cultural values, supporting rural livelihoods and preserving centuries-old sub-cultures. International recognition and protection, despite the global recognition of GIs, present challenges in their international protection. While some countries employ sui generis legislation to protect GIs, others rely on unfair competition and consumer rights protection laws (Rahmah, 2016). However, differences in legal frameworks among countries pose obstacles to international protection, highlighting the need for a harmonised approach (Abeysekara, 2011). Challenges in Sri Lanka's GI protection system can be considered *sui generis*, with the Intellectual Property Act providing special protection to GIs (Silva, 2015). However, existing provisions lack clarity, hindering the establishment of a comprehensive GI protection regime. The absence of provisions related to GI registration within the existing legal framework has led to various issues, including difficulties in protecting and promoting valuable GIs both domestically and internationally.

Strengthening the GI regime in Sri Lanka is imperative to ensure comprehensive protection and effective management of geographical indications domestically and internationally. This section highlights the need to address the deficiencies in the current legal framework, propose strategies for enhancing GI protection, and explore international best practices to promote the sustainable development of Sri Lanka's cultural heritage and economic interests (Wijesinghe, 2015). Geographical Indications (GIs) serve as crucial mechanisms to protect products originating from specific geographical locations, safeguarding their cultural heritage and economic interests. In Sri Lanka, the legal framework governing GIs faces notable challenges, particularly concerning registration procedures and international recognition. This section delves into the laws directly addressing GIs in Sri Lanka, primarily focusing on the Intellectual Property Act and its related provisions. The Intellectual Property Act, particularly Section 161, provides a specialised form of protection for GIs in Sri Lanka. This section stipulates that a GI denotes an indication identifying goods as originating from a specific territory where their quality, reputation, or other characteristics are essentially linked to their geographical origin. Additionally, various sections within the Intellectual Property Act, such as Sections 103, 160, 142(3), and 138(2), offer protection for GIs through trademark, unfair competition, certification marks, and collective mark provisions. Despite these legal provisions, challenges persist in establishing a comprehensive GI protection regime in Sri Lanka. The existing laws are often vague and lack clarity, hindering effective protection and management of GIs. Therefore, it becomes imperative to undertake extensive research on global geographical indication regimes and evaluate the mechanisms in Sri Lanka to address these shortcomings comprehensively. This research is important to various stakeholders, including policymakers, trade negotiators, producers, lawyers, economists, and individuals interested in the Sri Lankan economy. By identifying the deficiencies within the current GI regime, the research aims to propose strategies for establishing an effective geographical indication regime in Sri Lanka. This involves exploring potential reforms and policy measures to strengthen GI protection within the country's borders and enhance its competitiveness in international markets. The

Intellectual Property (Amendment) Act, No. 8 of 2022, introduced significant changes to the intellectual property (IP) framework in Sri Lanka. One of the key areas impacted by this amendment is the regulation of Geographical Indications (GIs). Thus, delve into what GIs are, how they are regulated under the amendment, the importance of these changes, and potential areas where further amendments might be needed. The Intellectual Property (Amendment) Act, No. 8 of 2022, made several changes to enhance the protection of GIs in Sri Lanka. Key provisions include as follow registration Process which is the amendment streamlined the registration process for GIs, making it more accessible and efficient. This involves defining clear criteria for what constitutes a GI and the process for applying and maintaining registration. Scope of Protection is the Act expanded the scope of protection for registered GIs, ensuring that not only the name but also symbols and other identifying features are protected against misuse and imitation. Enforcement mechanism discussion the amendment introduced stronger enforcement mechanisms, providing authorities with better tools to prevent and penalise the unauthorised use of GIs. This includes administrative, civil, and criminal remedies. International Alignment: in the Act aligns Sri Lanka's GI protection regime more closely with international standards, such as those outlined in the Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS). This alignment is crucial for facilitating international trade and recognition of Sri Lankan GIs abroad.

Furthermore, the study seeks to investigate international recommendations and best practices that Sri Lanka can adopt to improve its GI regime and gain recognition for its geographical indications on a global scale. Through addressing these research questions, this study aims to contribute valuable insights and recommendations to inform policy decisions and promote the sustainable development of Sri Lanka's cultural heritage and economic interests, thereby ensuring the comprehensive protection and effective management of geographical indications within Sri Lanka and in international operations.

2. METHODOLOGY

The methodology employed in this research ensures a systematic and thorough examination of the governance of Geographical Indications (GIs) in Sri Lanka by integrating scholarly opinions and employing a mixed-method approach that combines qualitative and quantitative data sources (Dagne, 2014). This comprehensive methodology encompasses several key stages, each contributing to a deeper understanding of the current landscape and potential areas for improvement in Sri Lanka's GI regime. The initial phase of the research involves an extensive review of existing literature on GIs, legal mechanisms, international standards, and best practices related to GI protection (WIPO, 2019). This literature review serves as the foundation for identifying research gaps and formulating pertinent research questions (March, 2007). Drawing from academic journals, books, legal documents, reports, and online databases, this review provides insights into the challenges and opportunities surrounding GI governance in Sri Lanka and other relevant jurisdictions. Following the literature review, primary data is collected through structured interviews and surveys with key stakeholders involved in GI governance in Sri Lanka. Stakeholders include government officials, legal experts, industry representatives, and academic researchers. These interviews and surveys aim to gather firsthand insights into the current status of GI protection, challenges faced, and potential avenues for improvement. The selection of participants is based on their expertise and involvement in GI-related activities, ensuring a diverse range of perspectives are captured. Subsequently, a comprehensive legal analysis is conducted to examine the existing legal framework governing GIs in Sri Lanka. This involves reviewing relevant legislation, regulations, and judicial decisions related to GI protection, with a focus on identifying gaps, inconsistencies, and areas for improvement. The analysis also considers scholarly opinions and international legal frameworks to provide a broader context for evaluating Sri Lanka's GI regime. A comparative analysis is then undertaken to compare Sri Lanka's GI regime with international standards and best practices. This comparative study particularly emphasises examining well-established systems for GI protection in other countries. Insights derived from this comparison offer valuable strategies and mechanisms for enhancing Sri Lanka's GI regime, including potential reforms and policy recommendations. Methodologically a deductive reasoning approach is adopted, grounded in legal theories applicable in Sri

Lanka and globally, to identify theoretical underpinnings governing areas related to GIs. Utilisation of both primary and secondary sources is emphasised, with primary sources presenting the law itself and secondary sources providing supplementary elucidation and details on similar jurisdictions. In terms of research style, the planned endeavour progresses through three distinct stages: explanatory, descriptive, and critical analysis. The explanatory phase delves into intellectual property law in Sri Lanka with a specialised focus on GIs. Meanwhile, the descriptive stage meticulously analyses laws in other jurisdictions, thereby facilitating a comprehensive understanding of the research scope. Finally, the critical analysis evaluates the adequacy of Sri Lankan jurisprudence in resolving issues within the intellectual property law domain and proposes reforms to address gaps in governing statutes. This methodology ensures a rigorous and comprehensive analysis of Geographical Indications governance in Sri Lanka, facilitating the development of well-informed recommendations tailored for policymakers and stakeholders.

3. RESULTS AND DISCUSSION

This analysis delves into the existing laws on geographical indications (GIs) in Sri Lanka, framed by insights from Prof. Althaf Marsoof's publication, "Advancing Geographical Indication Protection in Sri Lanka: Towards Legislative Reforms and Institutional Enhancements" (Marsoof, 2023). The discussion underscores the need for a robust legal framework to safeguard GI rights, evaluating current protection mechanisms, and identifying areas for improvement. By comparing Sri Lanka GI protection regime with advanced jurisdictions, such as the European Union (EU), the analysis highlights significant gaps and proposes lessons for strengthening the legal infrastructure in Sri Lanka.

Laws directly addressing GIs in Sri Lanka Intellectual Property Act No. 36 of 2003 is the primary legislation governing GIs in Sri Lanka. This Act defines a GI in Section 103 as indication which identifies any goods as originating in the territory of a country, or a region or locality in that territory, where a given quality, reputation or other characteristic of the good is essentially attributable to its geographical origin. This definition aligns with Article 22.1 of the TRIPS Agreement and extends protection to agricultural products comparable to wines and spirits. Section 160 of the IP Act prohibits unfair competition practices that are contrary to honest practices in industrial or commercial matters. Additionally, Section 186(1)(d) addresses false trade descriptions, criminalising the application of misleading geographical indications. The Act also provides mechanisms for protecting GIs through collective marks (Section 138) and certification marks (Section 142). Marsoof (2023) highlights that while the IP Act provides a foundational framework for GI protection, its implementation faces significant challenges. The lack of a centralised registration system impedes effective enforcement and leaves many GIs inadequately protected. For instance, only Ceylon Tea and Ceylon Cinnamon benefit from a regulated protection mechanism through the IP Act, supported by the Tea Board's trademark licensing. The scholarly consensus, including opinions from Yatawara & Rajapaksha (2008) and Wijesinghe (2015), suggests that indirect protections offered by unfair competition laws, consumer protection laws, and the common law principle of passing off, although beneficial, are insufficient for comprehensive GI safeguarding. These laws do not establish individual industrial property rights over GIs but prohibit unauthorised use that could mislead consumers.

Sri Lanka is a member of the World Trade Organisation (WTO) and a signatory to the TRIPS Agreement, which mandates minimum standards for GI protection. However, the country has not ratified the Geneva Act under the Lisbon Agreement, missing the opportunity for direct international registration of GIs without domestic registration requirements. Participation in international agreements like the World Intellectual Property Organisation (WIPO) underscores Sri Lanka's commitment to aligning with global standards. Yet, the limited engagement with instruments such as the Madrid Protocol for the international registration of marks reflects gaps in leveraging international mechanisms for GI protection.

The EU's GI protection system is widely regarded as one of the most robust in the world, exemplified by comprehensive registration mechanisms and strict enforcement policies. Among the key-cases, such as *Chateau de Beaucastel v. R & D Co*, highlight the EU's stringent approach to protecting GIs. The EU

framework includes a centralised registration system for GIs, facilitated by regulations such as Regulation (EU) No 1151/2012 on quality schemes for agricultural products and foodstuffs. This regulation ensures that GIs are protected and enforced uniformly across all member states. However, the lessons that Sri Lanka can draw from the EU's legal framework vividly discuss in Marsoof's research. Centralised registration system where the EU's centralised approach to GI registration ensures clarity, consistency, and ease of enforcement. Then establishing a similar system in Sri Lanka would provide a structured mechanism for registering and protecting GIs. Nest point bring into the table is independent regulatory bodies. The EU's system benefits from independent bodies that oversee GI protection and enforcement. Sri Lanka could enhance its framework by creating independent regulatory authorities dedicated to GIs, similar to the EU's bodies. Strict enforcement and clear guidelines one last opinion the EU legal framework offers clear guidelines and strict enforcement measures. Adopting such measures would ensure that GIs in Sri Lanka are adequately protected against misuse and infringement. Other than international recognition and registration open the lime light to the EU's participation in international agreements like the Lisbon Agreement allows for the global recognition and protection of its GIs. By ratifying international agreements like the Geneva Act, Sri Lanka could facilitate the global recognition of its GIs, providing broader protection and promoting international trade. Marsoof's publication highlights the inadequacies in Sri Lanka current GI protection regime and outlines a comprehensive roadmap for legislative reforms and institutional enhancements. By learning from the EU's robust GI protection system, Sri Lanka can strengthen its legal framework to better safeguard the rights and interests of local producers. Enhanced GI protection would not only preserve cultural heritage and traditional knowledge but also bolster economic growth by promoting local products in international markets. The recent amendments to the Intellectual Property Act, No. 8 of 2022, mark a significant step towards achieving these goals by offering clearer guidelines and stronger protections for GIs. However, further reforms are needed to establish a more comprehensive and effective GI protection system in Sri Lanka.

4. RECOMMENDATION

Flowing from the examination of Sri Lanka's current legal framework governing Geographical Indications (GIs) and considering insights from international practices, several recommendations emerge for establishing an effective GI regime in the country (Harvers, 2024).

Current legal system could be enhanced by strengthening existing provisions for GI registration. Although Sri Lanka has statutory provisions under the Intellectual Property Act No. 36 of 2003 and its relevant amendments for GI registration, these provisions need to be strengthened and more effectively implemented. Current challenges include inadequate enforcement mechanisms and lack of awareness among stakeholders to improve and enhance the current registration procedures to ensure clarity and efficiency. This could involve simplifying the process, reducing costs, and providing clear guidelines on the requirements and benefits of GI registration.

Establishing an independent regulatory body could create an independent regulatory authority dedicated to overseeing GI registration and enforcement. This body would maintain the registry, monitor compliance, and address infringements. Also, that can introduce comprehensive legal and procedural reforms to ensure a robust GI protection system. It is crucial to incorporate detailed procedural aspects and reforms.

Transparent and Impartial Procedures will ensure that the GI registration and enforcement processes are transparent and impartial, adhering to due process. This includes setting clear guidelines and timelines for registration, objections, and appeals. Leverage expertise can involve in legal professionals, economists, and international traders in the development of GI-related policies and procedures. That will ensure comprehensive and effective outcome aligned with international standards and practices. That could consider the evolving global landscape surrounding GIs. Sri Lanka should align its legal framework with international standards and practices. It is required to ratify the Geneva Act with the knowledge of exploring membership in the Geneva Act to facilitate the international registration of GIs, ensuring broader recognition and protection in global markets.

Active participation in international agreements and engagement in international forums and organisations dedicated to the protection of intellectual property and GIs, such as the World Trade Organisation (WTO) and the World Intellectual Property Organisation (WIPO), is required.

It is important to familiarise to use best practices from the European Union (EU). EU has one of the most robust GI protection systems, providing valuable lessons for Sri Lanka. Implementation of a centralised system for GI registration similar to the EU will ensure consistency and ease of enforcement across different regions and product categories. steps should be taken to adopt strict enforcement measures to protect GIs from misuse and infringement, drawing from the EU comprehensive regulatory framework. consumer awareness needs to be enhanced through effective promotion strategies, ensuring that the benefits of GIs are widely understood and appreciated. Additional Recommendations are to support small producers to assist small and medium-sized enterprises (SMEs) and local producers in navigating the GI registration process and maximising their economic potential.

It is recommended to establish a Dedicated Support Office within the Ministry to guide and assist with GI registration, offering resources and financial support. Cooperatives and associations can encourage the formation of cooperatives or associations to help small producers pool resources and strengthen their market presence. Enhancing technological integration leveraging modern technology to improve the traceability, authentication, and marketing of GI products, is also recommended.

Another common usage is implementation of blockchain technology. Blockchain technology for a transparent and tamper-proof system to track GI products from origin to market is required. Digital platforms and QR codes lead to develop digital platforms for registration and real-time updates, and use QR codes would enable consumers to verify the authenticity and origin of GI products easily.

Establishing monitoring and evaluation mechanisms will ensure that the GI protection system remains effective and responsive to new challenges and opportunities. Dedicated monitoring body can be set up to oversee the implementation and enforcement of GI regulations, conducting regular assessments and consultations with stakeholders. Annual reports published on the status and impact of GIs, highlight the successes and areas that need attention.

The comprehensive examination and updating of Sri Lanka's legal framework for GIs should incorporate recent legislative changes, international commitments, evolving best practices, and specialised dispute resolution mechanisms to ensure effective protection and promotion of geographical indications. Expanding upon these aspects with updated legal provisions will strengthen Sri Lanka's GI regime, ensuring comprehensive protection for its valuable geographical indications both domestically and internationally. The recent amendments to the Intellectual Property (Amendment) Act, No. 8 of 2022, have made substantial improvements, but further refinements are necessary to enhance the protection and utilisation of GIs.

5. CONCLUSION

Addressing the deficiencies and challenges in Sri Lanka's current geographical indication (GI) regime requires a multi-faceted approach, encompassing legal reforms, international engagement, and stakeholder collaboration. By incorporating international recommendations and best practices, Sri Lanka can establish an effective geographical indication regime to protect its valuable GIs and promote them both domestically and internationally. Through this research, valuable insights and recommendations are provided to inform policy decisions and contribute to the sustainable development of Sri Lanka's cultural heritage and economic interests. As highlighted by Danial Gervise, every nation possesses its geographical identity, which is an undeniable resource, emphasising the importance of protecting geographical indications for the benefit of the entire global community (Gervise, 2010). Sri Lanka, as a developing country, boasts a variety of natural resources with significant economic value, such as sapphire. While the Intellectual Property Act No. 36 of 2003 addresses GI-related issues, including interpretation, prevention, and protection, it lacks provisions for comprehensive GI registration, hindering international recognition and protection. The failure to ratify international instruments and the lack of professionalism among intellectual property law practitioners further impede the development of an effective GI framework in Sri Lanka. Additionally,

deficiencies in product specifications, controls, external certification, and accreditation for certification bodies contribute to the inefficiency of Sri Lanka's GI system. To overcome these challenges, Sri Lanka must consider either ratifying the Geneva Act to the Lisbon Agreement or establishing a dedicated GI register. A thorough comparison with well-established GI regimes, such as that of the European Union, highlights the need for clearer and more efficient procedures in Sri Lanka's GI framework. Therefore, it is imperative for Sri Lanka to implement an effective geographical indication regime tailored to its specific needs. Through such measures, Sri Lanka can enhance the protection and promotion of its geographical indications, contributing to both economic growth and cultural preservation. The Intellectual Property (Amendment) Act, No. 8 of 2022, marks a significant step forward in the protection and promotion of Geographical Indications (GIs) in Sri Lanka. By refining the legal framework and aligning with international standards, the amendments provide a robust foundation for leveraging GIs as tools for economic development and cultural preservation. Building on this solid foundation, the proposed recommendations aim to further enhance the GI protection regime. Increasing public awareness, providing targeted support to small producers, strengthening international cooperation, integrating technological advancements, and ensuring continuous evaluation are essential steps. Implementing these measures will allow Sri Lanka to fully realise the economic and cultural benefits of its unique Geographical Indications. By taking these proactive measures, Sri Lanka can enhance the protection and utilisation of GIs, contributing to sustainable development and global recognition of its rich heritage. Continued efforts in these areas will be key to maximising the benefits of GIs, ensuring that local communities thrive and that Sri Lanka's cultural and geographical heritage is celebrated worldwide.

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HYPOSENSE: AN INTEGRATED SENSOR DEVICE FOR HYDROPONICS FARM MONITORING

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ABSTRACT

In recent years, the monitoring of hydroponics farms has undergone a significant transformation due to the integration of sensors. However, the conventional method of manually observing measurements from multiple sensors has proven to be excessively time-consuming and costly. Additionally, the lack of automatic data recording options in most sensors has been a limiting factor. To address these challenges, we conducted an experimental study to introduce a novel integrated sensor device named "HypoSense", designed to monitor essential parameters such as temperature, humidity, pH, light intensity, Total Dissolved Solids (TDS), and Electrical Conductivity (EC) in hydroponic systems. HypoSense consists of three microcontroller units (MCUs) incorporated with two controlling circuits based on the Arduino platform: the Arduino UNO, ESP32, and the ESP8266 (NodeMCU) microcontrollers. The device is designed using high-precision sensors, including the DHT11 for temperature and humidity monitoring, an Analog pH sensor kit for pH measurement, BH1750 for light intensity, and an Analog TDS sensor kit for TDS and electrical conductivity measurements. These sensors were chosen for their reliability, accuracy, and compatibility with the Arduino platform, ensuring that HypoSense delivers precise and consistent readings. HypoSense is a cost-effective, portable sensor device specially designed for monitoring growth parameters simultaneously in hydroponic farming, saving growers time and effort. The evaluation was carried out in two phases. Firstly, field sensors were employed to calibrate HypoSense device sensors. Next, a secondary evaluation was conducted to confirm the practicality and user-friendliness of the HypoSense device. To facilitate the evaluation of HypoSense, we set up an indoor hydroponic system for growing tomatoes and lettuce. The results of these evaluations, focusing on the performance and applicability of the HypoSense device, will provide valuable insights for hydroponic growers and future researchers in precision agriculture.

KEYWORDS: *Hydroponics Cultivation, Internet of Things, Sensors, Growth Parameter Monitoring*

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1. INTRODUCTION

Hydroponics is an advanced technique for cultivating plants using water-based solutions instead of soil. It has gained popularity as an efficient and ecological method of agriculture because it enables sustainable and efficient crop production (Khan, 2018). Plants in hydroponic systems get all of their nutrients and water from a specific nutrient solution, and their roots are supported by inert materials like perlite, rock wool, or coconut fiber (Sardare, 2013). Hydroponics offers advantages over soil-based agriculture, such as lower water usage, greater control over plant growth conditions, and higher crop yields (Resh, 2022). Furthermore, hydroponic systems can be used in a variety of settings, including urban areas where traditional agriculture may be limited (RufíSalís et al., 2020). Several environmental factors such as pH, Electrical Conductivity (EC), Total Dissolved Solid (TDS), Temperature, Humidity, and Light Intensity must be monitored and controlled to maintain optimal plant growth and healthy plant conditions in hydroponic systems (Tagle et al., 2018). Failure to maintain optimal conditions can harm plant growth, cause nutrient deficiencies, and lead to plant death (Jones Jr, 2004).

Monitoring and maintaining optimal conditions in a hydroponic system can be challenging for small-scale individual growers. This is because they need to constantly check various parameters using separate, expensive devices regularly. Additionally, these devices do not have a built-in feature to store data after measurements are taken, so growers have to manually observe and record all the measurement data daily, which is a highly time-consuming process.

To address these limitations, we have designed and developed an innovative solution: HypoSense, an affordable, sensor-integrated, portable, and IoT-enabled device. This operates as an IoT-based multisensory system that is specifically designed for collecting data from hydroponic farming. The sensors used in this device allow simultaneous monitoring of all relevant parameters, and the collected data, along with the date and time, can be transmitted wirelessly and stored in a cloud.

Hence in this paper, we present HypoSense as a practical remedy to overcome the above challenges in hydroponic farming. HypoSense is a portable sensor device specially designed for monitoring growth parameters simultaneously in hydroponics farming. It is a cost-effective device that saves growers time and effort when compared to state-of-the-art devices available in the existing research.

The paper is structured as follows: In Section 2, we provide an overview of the current state-of-the-art IoT sensor-based research on hydroponics farming. Section 3 focuses on the development and design of the HypoSense device. We then discuss the evaluations we conducted on the HypoSense device in Section 4. Finally, in Section 5, we summarize our research findings, highlight the limitations of our study, and suggest directions for future research.

2. RELATED WORK

Over the last decade, hydroponic farming has greatly benefited from Internet of Things (IoT) technology. This technology has been utilized in large-scale hydroponics farms to monitor parameters such as pH, EC, light intensity, temperature, and humidity (Mehra et al., 2018), (Saha, 2021). IoT-driven hydroponics enables the remote surveillance and control of real-time system parameters, thereby facilitating decision-making capabilities through user-friendly interfaces (Lakshmanan et al., 2020).

Domingues et al. (2012), introduced an automated system for controlling pH and nutrient solution concentration, which was assessed in hydroponic lettuce production. This system enables continuous monitoring of pH and nutrient solution concentration 24 hours a day throughout the entire production cycle. Any variations can be automatically and instantly adjusted, resulting in increased productivity and the preservation of the nutritional quality of the product. The authors described the system as a fixed automated solution; however, they did not disclose pertinent details such as the financial investment and the electricity consumption required for continuous 24-hour operation within a greenhouse.

M. Fuangthong and P. Pramokchon, (2018) explored the use of fuzzy logic for the automatic control of electrical conductivity and pH in hydroponic systems

to reduce resource waste. While their research demonstrated the potential for improved control and precision, it faced several limitations. The study was constrained by the specific parameters and conditions under which it was conducted, potentially limiting the generalizability of the results to different hydroponic setups or crop types. Additionally, the implementation complexity and the need for specialized knowledge to fine-tune the fuzzy logic system are challenging for growers with varying levels of technical expertise. Moreover, the study did not extensively address the long-term reliability and maintenance requirements of the control system, which are critical factors for practical deployment in real-world farming scenarios. Recently, Chowdhury, et al. (2020) introduced an IoT-based automated vertical hydroponics indoor farming system in Qatar, highlighting advancements in automated agriculture. Notably, their system is independent of outside climate variations, and as a result of IoT, they can automate labor-intensive hydroponics farm maintenance tasks. However, the system scalability was not extensively tested, potentially limiting its application to large-scale operations. The setup lacks portability and requires substantially fixed and extra additional space. Additionally, the study did not deeply explore the long-term economic viability or the environmental impact of the system. The specific environmental conditions of Qatar may also limit the generalizability of the findings to other regions with different climates.

Additionally, the study conducted by Patil et al. (2020) proposed and designed an automated system that monitors various parameters of hydroponic systems. This system uses sensor-derived data to provide real-time access to the hydroponic system via a mobile application in order to monitor and enhance crop yield. The solution, however, lacks portability and requires a substantial amount of space for the setup.

H. Andrianto, Suhardi and A. Faizal, (2020) introduced a smart greenhouse system for hydroponics agriculture to measure temperature, humidity, TDS, pH, and light conditions. Moreover, they develop a mobile application that controls the IoT modules, to regulate the aforementioned measurement factors and facilitate optimal growth conditions for the plants. Further, Tatas et al. (2022) proposed a low-cost and low-power IoT-based system to control and monitor water quality, greenhouse temperature, and humidity in hydroponics farms. In addition to that they have used an inference engine to investigate the behavior of the plant irrigation. The authors have introduced both of these systems as low-cost IoT-based control and monitoring solutions for greenhouse hydroponics systems. However, the study lacks information regarding the incurred costs associated with the development, making it difficult to understand the total financial investment required. Moreover, the long-term feasibility, sustainability, and practicality of the solution in real-world applications are not clear.

The existing studies have explored the application of IoT in monitoring and controlling hydroponics systems' growth parameters, such as temperature, humidity, pH, TDS, and EC levels. However, there is a visible gap in the current state-of-the-art solutions. Many studies have not highlighted the cost incurred for setting up the IoT System. Hence it is required to emphasize cost-effective hardware development for creating a comprehensive solution capable of efficiently managing multiple parameters to drive actionable decisions in hydroponics farming. These solutions are fixed, lacking portability and handheld functionality, which restricts their flexibility and adaptability.

Small-scale hydroponic growers are less interested in investing a high cost in infrastructure. On the other hand, indoor growers do not prefer rigid setups because of space constraints. These setups cannot be easily moved or reconfigured, making it difficult to adapt to different growing conditions or experiment with new setups. Moreover, setting up a fixed IoT system for monitoring parameters can be complex and time-consuming, requiring specialized skills and knowledge that small-scale growers might lack. Therefore, small-scale hydroponic growers require cost-effective, portable, and handheld solutions to collect, store, and process multiple parameters simultaneously.

3. METHODOLOGY

In this research, we employed an ethnographic research methodology to understand the needs of hydroponic growers. We continuously observed daily operations, interactions, and challenges within hydroponics farming. The holistic understanding of the issues related to hydroponic farm monitoring was done through participant observation and in-depth interviews with domain experts. After analyzing expert knowledge and existing research, we developed a prototype to simplify hydroponic farm monitoring and reduce daily data collection issues.

In hydroponic farming, numerous growth parameters are required to ensure optimal nutrition levels and environmental conditions. The pH, TDS, EC of the nutrient solution, the lighting condition for photosynthesis, temperature, and humidity of the environment are to name a few essential parameters in Hydroponic cultivation. Hence, in designing HypoSense, we considered the aforementioned parameters and further explored the best sensor modules for accurate measurement of the parameters. Individual sensor modules were selected with the consultation of the field experts analyzing the cost to cater towards the cost-effectiveness of the designed solution. Iterative design strategies were employed throughout the design and development of the HypoSense device. The design was refined throughout the iterations to ensure the device's compactness and portability. We conducted frequent field trials and the feedback received through such trials was incorporated to enhance the user-friendliness of the device.

Software and Hardware Infrastructure

The device's control circuit was designed, incorporating advanced microcontrollers such as ESP8266 (NodeMCU), ESP32, and Arduino (UNO) to fulfill the needs of the hydroponic growers. To ensure compatibility with the main circuit, only Arduino-based sensors were utilized for collecting growth parameter data. Specifically, a BH1750 (GY-30) digital light intensity sensor and a DHT11 sensor were used for measuring environmental temperature, and humidity. Additionally, an Arduino-compatible Gravity Analog pH sensor and the Gravity Analog TDS sensor were utilized to measure the pH level, TDS, and EC values of the nutrition solution. Table 1 provides a summary and cost overview of the aforementioned hardware equipment. All prices are quoted for the year 2022/2023.

Table 1: Hardware Equipment used in HypoSense

Hardware equipment	Purpose	Price (USD)
Arduino (UNO)	Data collection and processing	8.52
ESP8266 (NodeMCU) and ESP32	Wireless communication to transfer data to the cloud	10.04
BH1750 (GY-30)	Measure light intensity	1.51
DHT11	Measure Temperature and Humidity	1.00
Gravity Analog pH sensor	Measure pH level	12.71
Gravity Analog TDS sensor	Measure TDS and EC values	10.70

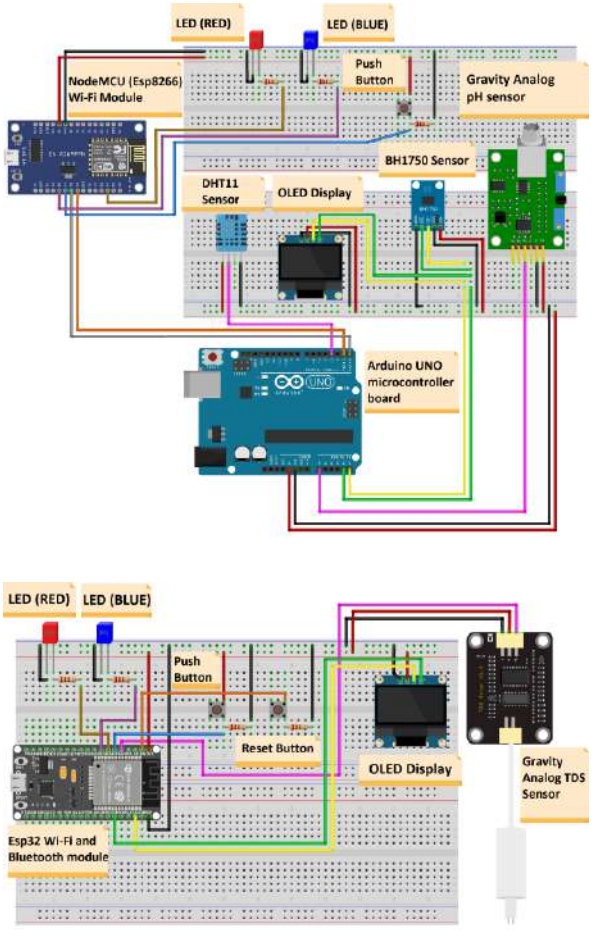

Figure 1: Circuit Diagram of HypoSense

Figure 1, provides a comprehensive visualization of the circuit diagrams employed in the development of the HypoSense device. It depicts the interconnection between the components in the structural design. We have conducted several field trials while designing the model. Measurements were obtained from the sensors to ensure the operational feasibility. Subsequent trials revealed an operational conflict between the pH and TDS sensors when measured simultaneously. In instances where the TDS probe and the pH sensor were immersed in the same nutrient solution, the pH sensor readings were observed to be unusually high. This phenomenon was attributed to the electronic pulses delivered to the nutrient solution by the TDS sensor during its operation.

The integrity of the system structure was improved to address the issues encountered. We have reassessed the sensor integration by conducting different operational protocols. We have come up with multiple designs, and the optimal one, prioritizing compactness and incorporating all refinements to ensure portability, was selected for the implementation of the device.

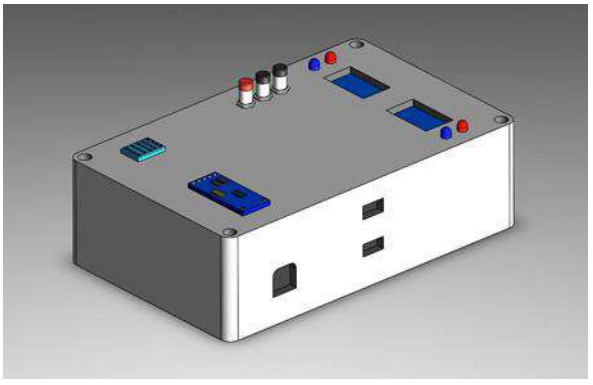

Figure 2: Three-Dimensional Visualization Model: Detailed Representation

Figure 2 shows the user visual representation of the detailed Three-Dimensional (3D) model designed to compact the circuit above. The 3D model visualizes the design elements, dimensions, and spatial relationships of the individual components, providing a comprehensive virtual rendering of the device's physical structure. We have designed several ports to facilitate the plug-and-play functionality of the sensors. Three control buttons were placed to control the data handling and data transfer. During the design phase, several research students were given a working model to measure parameters and transfer data. We observed their operation procedures to enhance the design. An OLED Display was used to display the multiple sensory values measured through sensors. The final alignment of elements was determined based on the practical working model of the solution and the ease of use of the device.

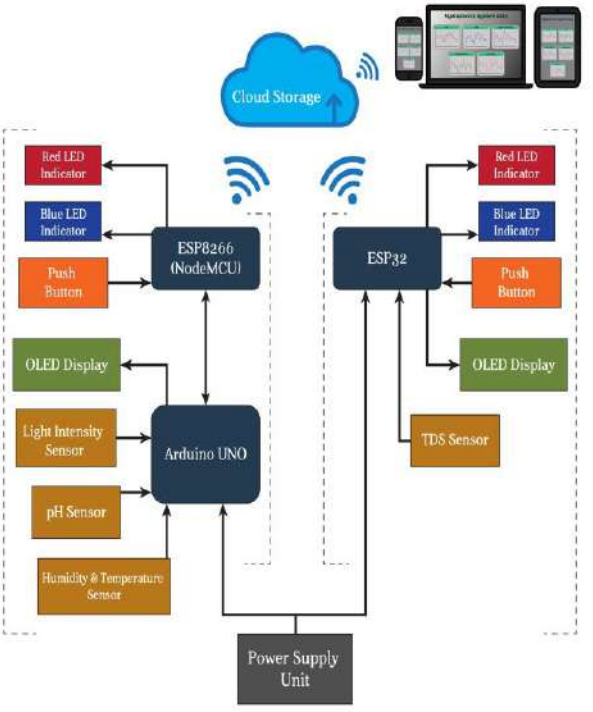

Figure 3: System Architectural Flow Model

The enhanced system architectural flow model of the HypoSense device is depicted in Figure 3. It visualizes the different components and their interaction. The collected data will be transferred to the cloud for further processing. The data stored in the cloud will be displayed to the user via a mobile application.

The final functional prototype of the HypoSense device implemented integrating the sensors is illustrated in Figure 4.The device was also designed with a portable battery to facilitate efficient data gathering over extended periods. Hence, the device is self-sufficient, making it highly portable as it doesn't rely on external power sources.

Figure 4: Final Functional Prototype of the HypoSense

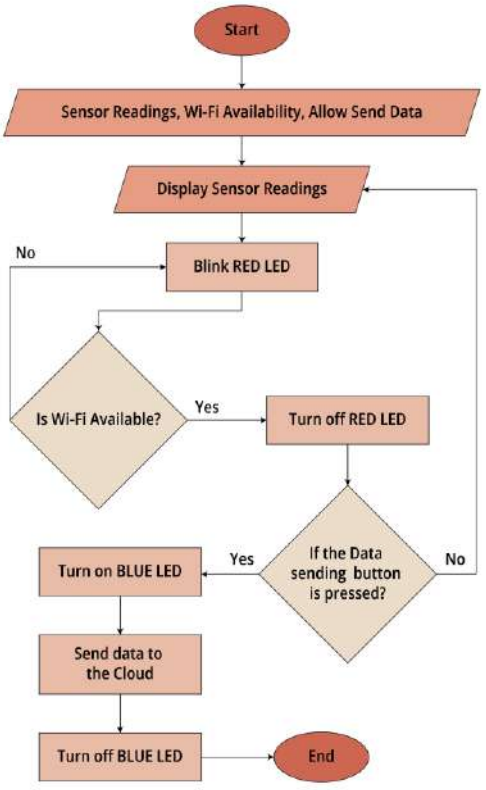

Figure 5: System Working Flow Chart

The system working flow chart of the HypoSense device is illustrated in Figure 5. The Arduino microcontroller acquires data from all the sensors and presents the readings on the OLED Display. We used several LED indicators to visualize the process to the end user. The end user will be notified of the status through the light and the blinking patterns. While the measurements are being recorded, the device's red LED indicator initiates a blinking pattern, serving as a visual cue for the ongoing process and indicating the sensor's Wi-Fi accessibility status. Once Wi-Fi connectivity is established, the red LED ceases to blink.

When measuring sensor readings, the user interacts with the device by pressing the dedicated send button to record the relevant data. The device's blue LED indicator lights up after the send button is pressed, indicating that the data has been stored.

4. RESULTS AND DISCUSSION

The evaluation of the "HypoSense" integrated sensor device was carried out to determine its effectiveness in measuring and recording the parameters in hydroponic farming. Our test was carried out using an indoor hydroponic system set up for growing tomatoes and lettuce (Figure 6).

Figure 6: Indoor Hydroponic System for Tomatoes

The evaluation was carried out in two phases. Initial evaluation was conducted using field sensors to calibrate the sensors of the HypoSense device. We assessed the accuracy of the HypoSense device by conducting a comparison with pH and EC measurements obtained using a device from the reputable brand "Extech." Renowned for its high accuracy in measuring environmental parameters, Extech devices are commonly utilized in industrial applications. Two Extech instruments were used for this comparison: the 'Extech PH100 ExStik' for measuring pH and the 'Extech EC400 ExStik' for measuring TDS and EC. The comparison involves assessing the performance of these instruments under controlled laboratory conditions and in real-world hydroponic settings. Two samples, mud water, and salt water, were utilized for this comparison. The measurements we received from both devices are illustrated in Figure 7 below.

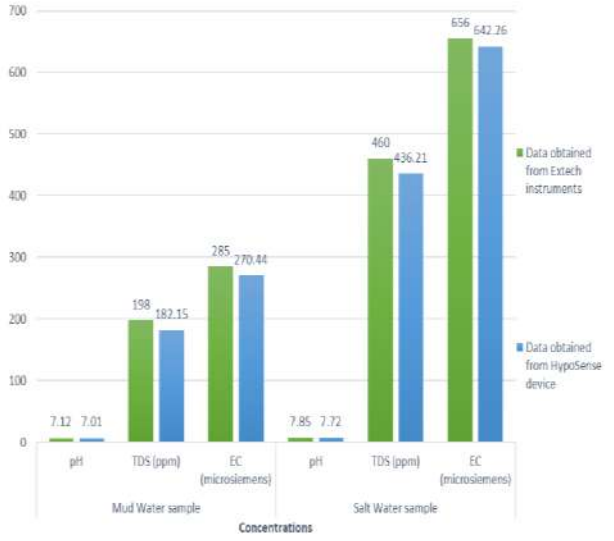

Figure 7: Value comparison with 'Extech' Industrial Instruments

The findings provide valuable insights into the accuracy of the HypoSense device for measuring nutritional parameters in hydroponic systems. In conclusion, the comparative analysis highlights the effectiveness of the HypoSense device in monitoring the parameters in a hydroponic system with high precision and accuracy.

The secondary evaluation was carried out to ensure the applicability and usability of the HypoSense device. A user questionnaire was used at that stage to gather feedback. A sample of 34 undergraduate students were selected for the evaluation out of which 76.5% were hydroponic growers and 23.5% were not. The user questionnaire covered aspects related to the sensor accuracy, ease of use, user-friendliness, power consumption, cost-effectiveness, ease of data acquisition, transmission, analysis, and user satisfaction.

First, we provided all the participants with a thorough understanding of how HypoSense works and how it is used. Then, the participants were given a 10-minute trial period to become familiar with the HypoSense device, as it was their first hands-on experience with using the device. All the selected participants used different, commercially available sensors to measure various parameters in the lab settings in their coursework. They were given specific instructions to follow a standardized protocol for collecting data in order to ensure accuracy and consistency. First, they used the standard lab sensors to measure the parameters. Then, they used the HypoSense device to take readings of the same parameters. Next, they were asked to compare the results with the readings from the HypoSense device. Finally, participants were given a questionnaire that comprised of Likert scale and open-ended questions. Users were asked to rate their level of satisfaction with the Likert Scale questions regarding the HypoSense device on a scale ranging from 1 (very unsatisfied) to 5 (very satisfied).

Accuracy and Precision

User satisfaction with respect to the device's sensor accuracy and precision was obtained to get an overall idea about the performance of the device. The results are summarized in Table 2, which shows an overall satisfaction rating of 4 out of 5, indicating good performance. The rating places the device at the median value in the overall assessment. However, improvement can be further done to increase the accuracy and the precision of the sensory equipment used in the device which we will address in commercializing the product.

Table 2: User Satisfaction w.r.t Sensor Accuracy and Precision

Name of the Parameter	Likert Scale Value				
	1	2	3	4	5
Temperature	0%	2.9%	5.9%	58.8%	32.4%
Humidity	0%	0%	23.5%	61.8%	14.7%
Light Intensity	0%	0%	3.2%	10.2%	86.6%
pH level	0%	3.9%	4.3%	37.7%	54.1%
TDS and EC level	2.9%	8.8%	29.4%	38.2%	20.6%

Usability

The HypoSense device was easy to use according to the majority of respondents. 32.4% were very satisfied and 64.7% were satisfied with the measuring process. Furthermore, we gathered user feedback on the ease of storing measured parameters with the HypoSense device for further analysis compared to other devices they currently use. As per the feedback, 79.5% of the users were very satisfied with the device's ability to store the measured parameters.

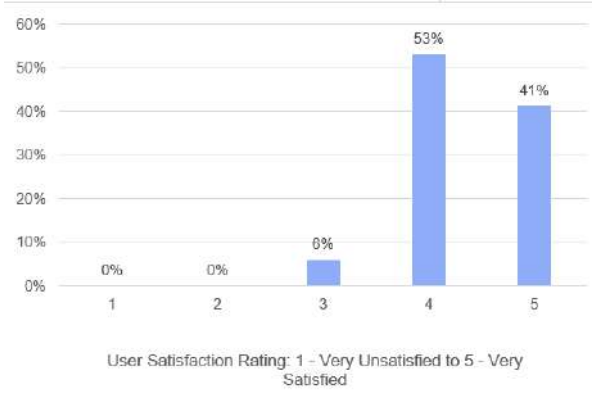

Figure 8: Overall User Satisfaction w.r.t Ease of Use.

The HypoSense device is used for measuring, collecting, and storing data related to hydroponics farming. As shown in Figure 8, the device is considered to be more user-friendly and easier to use than other alternatives available in the market. In a survey, approximately 41% of the respondents were highly satisfied with the device's ease of use, while the majority of users, accounting for 53%, found it satisfactory. A smaller group of users, comprising 6%, indicated that they found it to be average user-friendly. They mentioned that obtaining the measurements was difficult due to the external battery that had to be carried along with the device. As per the comments, we will look into the possibility of integrating the battery into the device to make it more portable in the future. Overall, the feedback suggests a high level of satisfaction with the device's usability and ease of use compared to the commercially available sensors that they are currently using in the lab settings.

Power Consumption and Cost-Effectiveness

Many of the users agreed that by using a single device they can easily measure parameters within seconds compared to the conventional methods. They also mentioned that this is a time and cost-effective solution rather than using different sensors to measure the parameters separately. Further, many agreed that the device consumes less electricity and the power bank was sufficient for obtaining the readings for more than 8 Hrs. As per the user feedback, majority around 62% were satisfied with the power consumption of the HypoSense device.

In addition to that majority agreed that it is a cost-effective solution to obtain accurate parameter measurements within a short period of time. In addition to the user survey, we conducted a comparative analysis to compare the prices of industrial equipment with those of the HypoSense device, as shown in Table 3.

Table 3: Price Comparison: Industrial Equipment vs. HypoSense Device

Device	Measurable Parameters	Price (USD)
HypoSense	Temperature, Humidity, Light Intensity, pH level, TDS and EC levels	55.19
Extech PH100: ExStik® pH Meter	pH level	103.99
Extech EC500: Waterproof ExStik® II pH/ Conductivity Meter	Conductivity, TDS, Salinity, pH, and Temperature	181.99
Extech 401025: Foot Candle/Lux Light Meter	Light Intensity	159.99
Extech 445580: Humidity/Temperature Pen	Humidity, Temperature	74.99

Accordingly, HypoSense is capable of measuring a wide range of parameters compared to other devices. Specifically, only the Extech brand meter offers measurements for Conductivity, TDS, pH, Salinity, and Temperature. However, none of these industrial devices have built-in data storage or the ability to send data to a cloud server with timestamps. In comparison, the cost of the HypoSense device is much cheaper than other industrial devices as illustrated in Table 3. Hence we claim that the device is a cost-effective solution to measure the most required parameters for Hydroponic Growers.

Ease of Data Collection, Transmission, Analysis and Deriving Insights

The majority of users expressed satisfaction with the device's ability to collect real-time data. Specifically, 50% of the sample reported being highly satisfied, while approximately 47% reported being satisfied. Only a small minority, about 3%, reported being neutral. Moreover, approximately 94% of users were highly satisfied or satisfied with the data transfer process and reported no delays. Overall, users were satisfied with the device's decision-making capabilities, and the visualization of the users' perspective is illustrated in Figure 9.

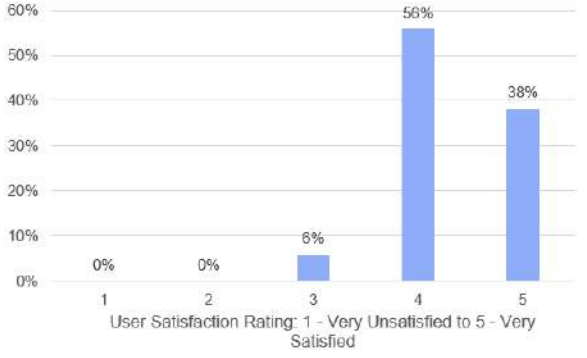

Figure 9: Overall User Satisfaction w.r.t Decision-Making Capabilities

In addition to that many highlighted the need to measure the nutrient concentrations in Hydroponics including Nitrogen(N), Phosphorus(P), and Potassium(P), which we will consider in the future enhancements of the device.

Overall Satisfaction and User Recommendations

Users have provided feedback on their overall satisfaction with the HypoSense device, which highlights its significance in hydroponics farming. They found the device to be extremely valuable, especially for its ability to measure various parameters and effectiveness. Its ease of use in the hydroponics field was also appreciated by over 90% of users. The device's effectiveness in achieving its intended purpose was acknowledged by the majority, as it performed efficiently in terms of collecting, transmitting, and analyzing data, empowering users to make informed decisions. Additionally, more than 90% appreciated the device's ability to consistently deliver accurate data that enables growers to make informed decisions and maintain optimal growth conditions for their plants.

Users have provided some recommendations for enhancing the device. The majority suggested including an internal power supply or a solar-powered solution, to make it more portable and cost-effective. Many have emphasized the importance of getting this to farmers, as it has the potential for wider adoption. Suggestions were given to improve user-friendliness by enhancing the interface and slightly increasing screen size. Additionally, users suggested broadening the device's measurement capabilities, minimizing its physical size for improved portability, and adapting it to measure new parameters in hydroponics systems. They also highlighted the importance of the inclusion of alert and notification features for real-time monitoring and automation. These insights offer a comprehensive view of user perspectives, highlighting the strengths and weaknesses and providing a clear path for future development and optimization of the HypoSense Device.

Based on Figure 10, the overall performance satisfaction of the device ranged from 6 to 10, with no responses falling below 5. The majority, 79% of users, rated the device's overall performance as satisfactory, providing scores between 8 and 10 indicating a very satisfactory level.

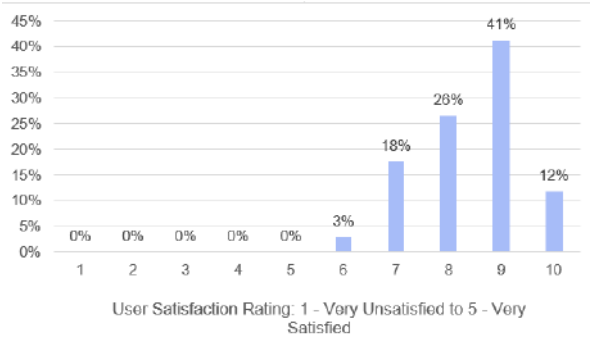

Figure 10: Overall User Satisfaction w.r.t Performance.

On the other end, Figure 11 illustrates the high willingness of users to recommend this device to hydroponic growers, with ratings ranging from 7 to 10 on a 10-point scale. This indicates that users found the device not only effective and reliable but also beneficial for improving hydroponic farming practices. The high scores suggest that users believe the device significantly enhances the monitoring and management of essential growth parameters such as temperature, humidity, pH, light intensity, Total Dissolved Solids (TDS), and Electrical Conductivity (EC).

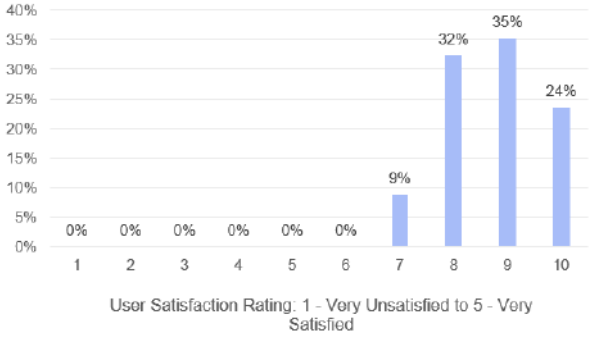

Figure 11: User Willingness in Recommending the Device to Those Who Grow Hydroponics.

This positive feedback reflects the device's overall usability, user-friendliness, and value in providing accurate and actionable data, thereby making it a valuable tool for both novice and experienced hydroponic growers.

5. CONCLUSION

Hydroponics is one of the most widely used cultivation methods that help increase crop production to satisfy urban food needs. Recent trends also show that people are increasingly interested in growing hydroponics to produce their daily healthy food needs. Mostly, hydroponics are carried out indoors to reduce the difficulties associated with outdoor hydroponics. However, due to natural light's limitations, and the need for measuring the parameters regularly, indoor hydroponics can present certain difficulties.

To address these challenges, we introduced a novel integrated sensor device for hydroponic farm growth parameter monitoring. The conventional method of manually observing measurements from multiple sensors has proven to be excessively time-consuming and costly. Additionally, the lack of automatic data recording options in most sensors has been a limiting factor. When compared to commercially available devices HypoSense is a cost-effective device that saves growers time and effort to measure essential parameters in Hydroponics farming. Compared to state-of-the-art solutions available in the existing research, HypoSense is a portable device tailored for the simultaneous monitoring of growth parameters in hydroponics farming. In particular, HypoSense can monitor temperature, humidity, pH, Light intensity, total dissolved solids, and electrical conductivity.

We evaluated the overall performance of the HypoSense device using a sample of 34 users. The overall results highlighted overall user satisfaction. They found the device to be extremely valuable, especially for its ability to measure various parameters and effectiveness. Its ease of use in the hydroponics field was also appreciated by many users. The ability of the device to continuously obtain data within a short time period will enable growers to make optimal decisions at the right time.

The feedback provided by users is highly valuable for the future development and improvement of the HypoSense device. It sheds light on practical considerations and features that users believe can further optimize the HypoSense device for the benefit of hydroponic farming and its users.

6. ACKNOWLEDGEMENT

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ESTIMATION OF CLARK Y-14 AIRFOIL'S LIFT HYSTERESIS IN LOW-SPEED FLOW

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ABSTRACT

A phenomenon called hysteresis is responsible for the difference in the separation and the reattachment angles of an airfoil which is seen within the vicinity of the stalling angle of attack. The reason for this is the difference in the expected lift distribution of an airfoil for a particular angle of attack when recovery from stall is achieved. This leads to asymmetric flow parameters around a body even when the boundaries remain symmetric. Empirical results were obtained for a two-dimensional Clark Y-14 airfoil by varying the angle of attack for different Reynold's numbers in order to estimate how lift characteristics are affected by the formation of hysteresis loops at different Reynolds numbers. It was seen that the extent of the clockwise hysteresis loops of the Clark Y-14 increased with the increase of the Reynolds number up to the Reynolds number of 134072 before starting to decrease again. The stalling angles followed a similar pattern before starting to decrease at a Reynolds number of 164543. These trends observed for the Clark Y-14 airfoil is similar to that of the Eppler 591 and NACA 0018 by Lance W.Traub and W.A Timmer respectively (Timmer, 2008), (Traub, 2016). *When analyzing the coefficient of pressure variation for the Clark Y-14 airfoil at a particular Reynolds number, it was seen that a laminar separation bubble was formed for the forward stroke which shifted towards the leading edge of the airfoil which was common for all the Reynolds numbers. In the forward stroke, it could be seen that a laminar separation bubble was formed whereas for the backward stroke no such laminar separation bubble was formed for the same angle of attack which gave rise to the hysteresis loops of the Clark Y-`14 airfoil. It was observed that the laminar separation bubble had a direct impact on the formation of the hysteresis loops giving rise to static stall hysteresis as mentioned in previous research published by various authors. The empirical results obtained were further validated using Computation Fluid Dynamics.*

KEYWORDS: Coefficient of pressure, Lift hysteresis, Lift curve, Flow separation, Stall

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1. INTRODUCTION

Aerodynamic hysteresis can be defined as the change in aerodynamic properties as they become history dependent. Put into simple words, it is the existence of multiple values of coefficient of lift, drag and moment instead of a single value depending on the sense of the angle of attack. Hysteresis is mainly of two types, namely conventional (static hysteresis) and dynamic hysteresis (Williams, et al., 2015). Conventional hysteresis is seen when the airfoil is pitched very slowly above the stalled condition and slowly pitching it back down. If we consider the coefficient of lift, here we could observe two distinct values for this aerodynamic property for the same angle of attack depending on whether the angle of attack was increasing or decreasing giving rise to a hysteresis loop. Dynamic hysteresis on the other hand is seen when an airfoil is in motion. Conventional hysteresis need not be present for dynamic hysteresis to occur in aerodynamic coefficients when the flow is separated.

The most common type of hysteresis that is seen in airfoils is the static stall hysteresis which is seen near classic stall. It is necessary to reduce the angle of attack significantly below the pre catastrophic stalling angle of attack in order to reattach the flow and recover the lost lift during stall. Depending on the hysteresis loop formed hysteresis loop could either be clockwise or anticlockwise (Traub, 2016).

Various factors affect this so formed Hysteresis loops in the aerodynamic coefficients such as the Reynold's number (Brunner, et al., 2021), Turbulence intensity (Hoffmann, 1991), type of separation bubble formed (Marchman, 1987), effective body of the airfoil (Landman, 2001) and the boundary layer separation and the separation on the airfoil (Landman, 2001), (Timmer, 2008), (Traub, 2016). Even though various research has been conducted regarding static stall hysteresis on various types of airfoil, very few have been conducted on a Clary Y airfoil. These do not sufficiently discuss the hysteresis effects of this particular airfoil and its behaviour at different Reynolds numbers. This research was conducted with the intention of providing a detailed idea about how the Clark Y-14 airfoil behaves in the said Reynolds number range and how lift characteristics are affected due to the presence of hysteresis in the said airfoil. Clear understanding of lift characteristics of an airfoil under hysteresis is of utmost importance as it would be extremely dangerous since stall recovery requires a large decrease in angle of attack contrary to a simple reduction of back pressure on the controls. The nature of the stall becomes much more complicated in low Reynolds numbers due to laminar separation bubbles which may form before full stall and various other factors that might influence it. Hence having a better understanding of how the Clark Y-14 airfoil reacts to hysteresis will be much beneficial. A component of this research was done previously which gave rise to some interesting facts regarding the relationship of the Reynold's number with the formation of the hysteresis loops and the continuation of the research further gave rise to some more insight on how the laminar separation bubble plays a role in the formation of the hysteresis loop in the Clark Y-14 airfoil and the validation of the empirical results through CFD simulations which is discussed in this paper.

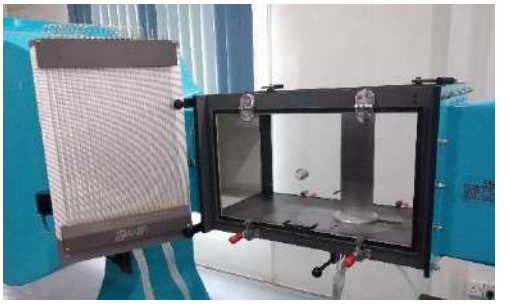

Figure 1. Wind Tunnel Apparatus

2. METHODOLOGY

The initial stage included carrying out of wind tunnel experiments in order to find the relationship of the Reynold's number on the extent of the hysteresis loop. The Reynolds number range was selected by considering the limitations of the AEROLAB Educational Wind tunnel at Kotelawala Defence University which was used for conducting of the test. The wind tunnel has a test section of 30.5 cm × 30.5 cm × 30.5cm and a speed range of 4.5 m/s to 64 m/s. The AEROLAB pressure wing resembling a Clark Y-

14 airfoil with a chord of 8.9cm having 18 flush mounted taps was mounted on the test section and pressure readings via a multi tube manometer was obtained.

The experiment was conducted by varying the angle of attack of the pressure wing by multiples of 1 degree for the forward (increasing the angle of attack until the airfoil stalls) and the backward stroke (decreasing the angle of attack back from stall). MATLAB was used in order to calculate the coefficient of lift by integrating the area between the upper and lower surface of the airfoil of Cp Vs X/C graph.

The next stage of the research consisted of carrying out of CFD simulations in order to validate the obtained wind tunnel results. The simulations were carried out for a Reynolds number of 134072 corresponding to wind tunnel RPM of 800 using ANSYS 2021 R1 software.

The Computational flow domain used to analyse the Clark Y-14 airfoil of non-dimensional chord length of 1m is a C type mesh consisting of a frozen layer which radiates 3 times the chord from trailing edge towards the forward and 5 times the chord towards the aft. The entire grid extends 10 times the chord from the trailing edge and 60 times the chord behind the airfoil. Inflation layers were used in order to better capture the effects near the boundary layer.

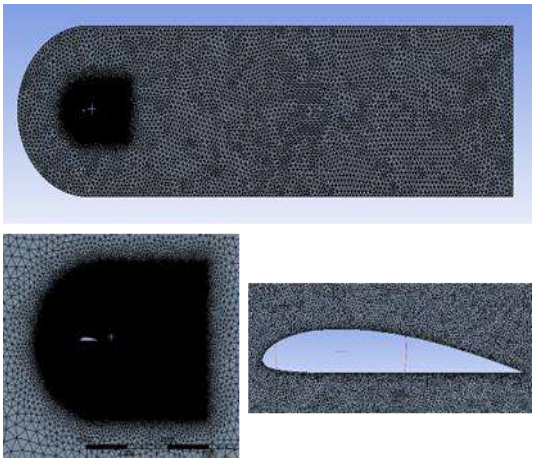

Figure 2. CFD Mesh

The Kω SST turbulence model was used with a velocity inlet and a pressure outlet for the domain. The lower and upper boundaries of the domain was set to wall and the convergence criteria was set to 1e-06.

3. RESULTS AND DISCUSSION

The coefficient of pressure variation and the relationship of the extent of the hysteresis loop with Reynold's number was discussed earlier. It was seen that the extent of the clockwise hysteresis loops increased with the Reynold's number up until a Reynold's number of 134072 before starting to decrease again for the Clark Y-14 airfoil.

The stalling angle too followed a similar pattern. The stalling angle continued to increase until a Reynolds number of 146260 before starting to decrease again. The summarised results from the Research paper are given below. These trends shown by the Clark Y-14 airfoil is similar to that of the findings by Lance W. Traub and W.A. Timmer for the Eppler 591 and NACA 0018 airfoils, respectively.

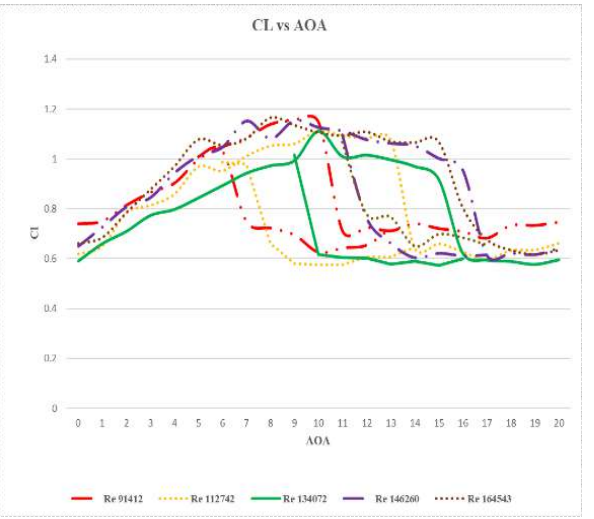

Figure 3. Hysteresis Curves for different Reynold's numbers

Table 1: Extent of hysteresis loop with Reynold's number

Reynolds number	Extent of hysteresis loop	Presence of hysteresis loop
60941	negligible	-
79224	negligible	-
91412	6° - 11°	4°
112742	7° -14°	7°
134072	9° -16°	7°
146260	11° -17°	5°
164543	11° -17°	5°

Table 2. Stalling angle variation with Reynold's number

Reynolds number	stalling angle
91412	above 10°
112742	above 13°
134072	above 15°
146260	above 16°
164543	above 15°

Furthermore, by studying the coefficient of pressure variations, it was discovered that a laminar separation bubble was formed. By considering a particular Reynold's number and looking at the coefficient of pressure graphs, it was seen that a nearly constant pressure region (plateau region) was found at a certain location and a sudden increase in the surface pressure following the plateau region. It was further observed that the surface pressure recovered gradually and smoothly downstream of this region. These features characterize the formation of a laminar separation bubble where the laminar boundary layer separates followed by transition and reattachment creating a bubble (Traub, 2016).

By considering a particular Reynold's number of 146260 and looking at the coefficient of pressure variation for different angles of attack, it was observed that the laminar separation bubble is formed at locations of X/C of 0.5, 0.3 and 0.05 for angles of attack of 0,5 and 15 degrees respectively. This shows that the laminar separation bubble has continued to move upstream of the airfoil towards the leading edge with the increase of the angle of attack. This phenomenon was common to all the Reynold's numbers for which the experiments were conducted on.

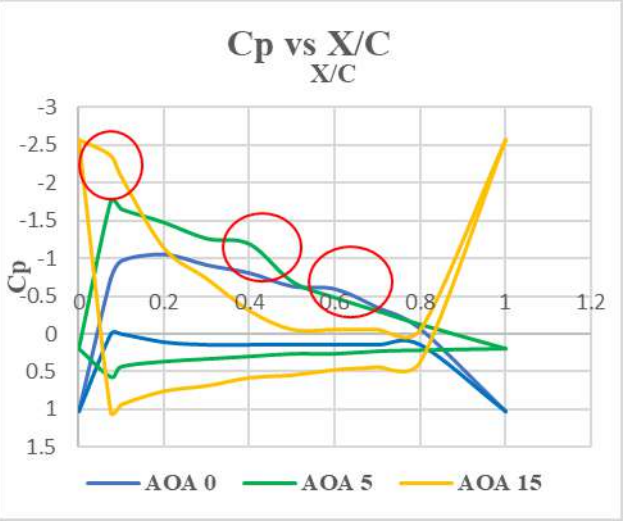

Figure 4. Coefficient of pressure variation at Reynold's number of 146260 for different angles of attack

It was seen that for the Reynold's number of 134072 at 15 degrees, for the forward stroke a separation bubble was formed at a location of X/C nearly equal to 0.05 which is evident from the pressure plateau and the flow separates at a location of X/C nearly equal to 0.5 from the upper surface. But when it comes to the backward stroke, there is no evidence for a formation of a laminar separation bubble and instead the flow over the upper surface is seen to separate closer to the leading edge with no reattachment to be seen leading to a great loss of lift which was observed by looking at the coefficient of lift curve corresponding to the particular Reynold's number. For the angle of 18 degrees the separation bubble had burst in the forward stroke and the flow does not reattach after separation and the coefficient of lift has drastically decreased with almost identical behaviour seen in the backward stroke as well.

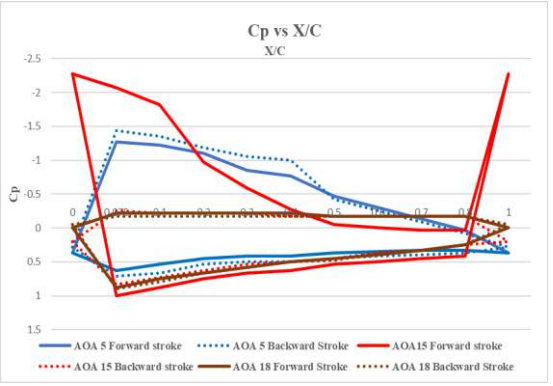

Figure 5. Cp variation for different angles of attack for Re of 134072

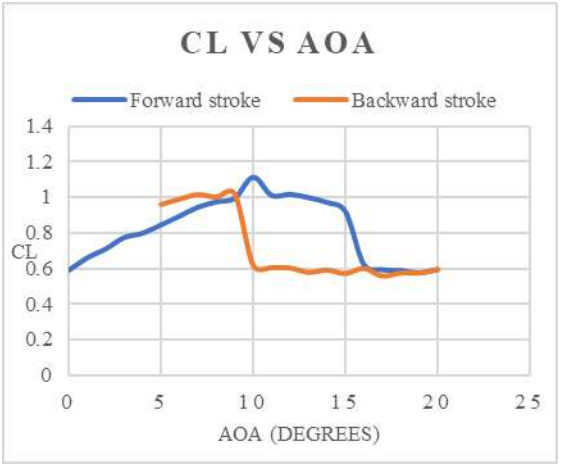

Figure 6. Cl variation for forward and backward stroke at Reynolds number of 134072

During the forward process it is seen that the flow separates and reattaches forming a laminar separation bubble which results in a higher lift while for the backward stroke the separated flow does not reattach and form a bubble and the flow continues to stay separated for the same angle of attack range diminishing the lift characteristics of the Clark Y-14 airfoil resulting in a clockwise hysteresis loop (Traub, 2016). Hence it can be seen that the formation of the clockwise hysteresis loops for the lift characteristics of the Clark Y-14 airfoil has a strong relationship to the formation of the laminar separation bubble which is in agreement with previous research that has been published on various other airfoil types (Marchman, 1987), (Sarlak et al., 2018), (Traub, 2016).

The CFD simulations that were run in order to validate the experimental results are given in Table 3.

Table 3. Comparison of wind tunnel and experimental results

AOA	CL simulation (KW SST)	Cl experimental	Error	Error %
0	0.53176	0.5899	0.05814	10%
2	0.6957	0.7087	0.013	2%
4	0.8339	0.7969	0.037	5%
6	0.91764	0.8924	0.02524	3%
8	0.96831	0.9724	0.00409	0%
10	0.807883075	1.1103	0.30242	27%
12	0.683735777	1.015	0.33126	33%
14	0.64579816	0.9694	0.3236	33%
16	0.65	0.6216	0.0284	5%
18	0.5974	0.5883	0.0091	2%
20	0.59685	0.5947	0.00215	0%

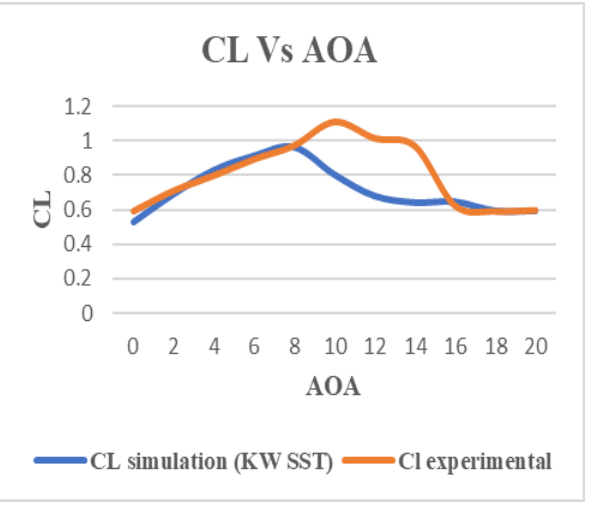

Figure 7. Cl vs AOA for Wind tunnel and CFD results

The wind tunnel results and the CFD results are almost identical for low angles of attack and very high angles of attack above 16 degrees with an error percentage of less than 10%. The results within the region of 10-14 degrees shows a very high deviation from the experimental results. The turbulence model

has interpreted flow separation prior to that of the experimental results which gave rise to this deviation. The model has been unable to predict the stalling point of the airfoil accurately. This could be because of the high amount of randomness and turbulence within the stalling vicinity and the lesser amount of refinement of the CFD mesh due to the lack of computational power to further refine the mesh in order to capture these phenomena and the time constraints available. It is safe to say that the CFD results has validated the experimental results up to a certain extent but was not able to predict the flow behaviour near the stalling region, hence it is not appropriate to come to conclusions based on the values obtained within this region.

The pressure contours and the streamlines at different angles of attack was analysed in order to get a better understanding regarding the flow over the airfoil. By looking at the dynamic pressure contours it was seen that the flow over the airfoil was initially fully attached and with the increase of the angle of attack the wake behind the airfoil continued to increase. It was also seen that the path followed by the flow field is not that of the physical body of the airfoil and instead it is of a different shape. The path followed by the flow might be the effective body of the stalled airfoil rather than its physical body which might have been the reason for the occurrence of hysteresis loop and why a stalled flow persists even when the angle of attack is reduced below the staling angle. The angle of attack of the stalled airfoil needs to be reduced to an angle lower than that of the effective body's stalling angle in order to reattach the flow as stated by Morris II et al. for a symmetric airfoil (Morris, et al., 2020). This is to be further studied by conducting experiments on an effective body of the stalled Clark Y 14 airfoil.

4. CONCLUSION

A two-dimensional asymmetric Clark Y 14 airfoil was observed in low-speed flows by varying the parameters of angle of attack and Reynold's number.
It was observed that the Reynold's number and angle of attack are primary parameters that have an impact on the occurrence of hysteresis loops in static stall hysteresis of the Clark Y-14 airfoil and the size of the so formed hysteresis

It was observed that a clockwise hysteresis loop was formed for the lift characteristics of the Clark Y-14 airfoil where the extent of the Hysteresis loop increased with the Reynolds number where the maximum could be seen at Reynolds number of 134072 before starting to decrease again. The stalling angle of attack of the said airfoil too followed a similar pattern where the stalling angle increased with the Reynolds number before starting to decrease at a Reynolds number of 146260. These patterns observed are similar to the hysteresis loops observed for the Eppler 591 and NACA 0018 airfoils by Lance W. Traub and W.A. Timmer respectively.

The coefficient of pressure curves of the Clark Y-14 airfoil showed a laminar separation bubble forming which shifted towards the leading edge of the airfoil with the increase of the angle of attack for all the Reynolds numbers for which the experiment was conducted. For the forward stroke it was seen that a laminar separation bubble was formed, but for the backward stroke no such laminar separation bubble was formed, which led to a drastic decrease in the lift characteristics of the backward stroke giving rise to a clockwise hysteresis curve for the Clark Y-14 airfoil.

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COMPETITIVENESS OF SRI LANKAN TEA IN THE INTERNATIONAL MARKET: A TRADE FLOW ANALYSIS

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ABSTRACT

For more than 150 years, Sri Lanka has had a significant influence on the world market for tea. Sri Lanka is one of the world's top producers and exporters of tea. However, Sri Lanka's tea industry encounters a number of challenges due to internal and external market conditions, including governmental regulations, rising labour costs, and supply chain disruptions. These challenges can affect the competitiveness of Sri Lanka's tea exports in the global market. Therefore, it is important to understand how the competitiveness of Sri Lankan tea exports in the global tea market changed over time. The specific objectives of the study were to examine the relative contribution of Sri Lanka's tea exports to the international market and to assess the level of competitiveness of Sri Lanka's tea exports. Based on the positivist research philosophy and quantitative approach, this study adopted four indexes to assess the level of competition. These indices include export market share (MS), export unit price (EUP), revealed comparative advantage (RCA), and revealed trade advantage (RTA). The study's findings demonstrated that while the export unit price exhibited an upward trend, Sri Lanka's market share in the world tea market has decreased over time. According to the findings of the RCA and RTA indices, Sri Lanka's competitiveness in terms of international tea exports has continuously decreased. Kenya, on the other hand, has witnessed a rise in tea export competition, while China and India have seen a decline in tea export competition. This study emphasizes the need for implementing efficient production methods in order to provide Sri Lankan tea to the global market at a lower price. Additionally, government policies ought to focus on offering technical assistance to boost productivity in the Sri Lankan tea industry.

KEYWORDS: *Competitiveness of Sri Lankan Tea, Trade Flow Analysis, Revealed Comparative Advantage, Revealed Trade Advantage*

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1. INTRODUCTION

Since its inception in 1867, Sri Lanka's tea business has been significant in terms of its contribution to national output, employment, and net foreign exchange earnings. Over the past 150 years, the sector has undergone a variety of changes. Large-scale tea plantations that were privately owned at this time have given way to nationalized plantations run by the government, which are now regional plantation enterprises controlled by private companies (Arunatilake, Wijayasiri, & Kelegama, 2018). The smallholder segment of the tea business has expanded recently, surpassing tea estates as the primary source of tea production in the nation. Many other aspects of the industry are also evolving quickly, including the rise of the small holder tea sector, labour concerns, automation, shifts in consumer demand, climate change, and proliferation of quality requirements. (Arunatilake, Wijayasiri, & Kelegama, 2018).

Along with the constraints of the domestic market, recent changes on the global market have made it more difficult for Sri Lanka to produce tea. International tea prices fell to USD 2.44 per kg in 2021 as trading was hampered by logistical problems brought on by the pandemic. Prices began to improve in the final quarter of 2021, averaging USD 2.62 per kg (FAO, 2022). The increase was brought on by significant increases in the Colombo auction market, which followed tighter supply coming from Sri Lanka as a result of the country's economic difficulties and high global demand. The Russia-Ukraine conflict, however, had a negative effect on tea prices and trade because the Russian Federation is the second-largest importer of Indian tea, the third-largest importer of Sri Lankan tea, and the fifth-largest importer of Kenyan tea. Since the Russian Federation is a key provider of fertilizers, their scarce supply and/or rising costs could result in poorer yields and lower tea quality.

Based on these internal and external issues, there is tremendous uncertainty about how Sri Lankan tea's competitiveness may change in the global market. The literature that is currently available on Sri Lankan tea production does not fully support the analysis of how Sri Lankan tea's competitiveness has changed over time in the international market.

Literature confirms that even though there are a number of studies that examine Sri Lanka's tea sector, the studies that examine how Sri Lanka's tea sector's competitiveness changed over time are narrow and limited.

Therefore, the purpose of this study is to conduct a descriptive trade flow analysis in order to assess how competitive Sri Lankan tea is on the international market. This study is significant in filling the literature gap regarding the changes in Sri Lanka's competitiveness in tea exports to the international market. Such knowledge is essential for the effective formulation of policies that will advance the Sri Lankan tea industry. However, as a limitation, this study does not examine the impact of the COVID-19 pandemic, the Russia-Ukraine war, or Sri Lanka's economic crisis on tea exports and its competitiveness since it covers only the period spanning from 2002 to 2021.

2. LITERATURE REVIEW

The tea plantation has been restricted to five unique places in the world due to the unique conditions of the soil and environment. The majority of tea-producing nations are found in the Asian continent. The leading producers on the continent are China, India, and Sri Lanka. The African nations that produce the most of their tea include Kenya, Tanzania, Malawi, and Uganda, which are all located in tropical climates (Kithsiri, V.S. Jayamanna, & Abewickrama, 2020). Kenya, China, India, Sri Lanka, Vietnam, and Malawi are the very active nations that compete with one another in the ferocious tea industry environment. These countries are the leading producers and exporters of tea in the world (Kasturiratne, 2008). When it comes to the current rankings of tea exporting nations, China is in the first place as the biggest exporter, followed by Kenya and Sri Lanka in second and third places, respectively. India and Poland round out the top five (Cybex, 2022). Therefore, this study selected China, Kenya, Sri Lanka, and India to compare their levels of market competition.

The tea business must maintain sustained competition with other global producers and exporting nations in order to benefit the nation's economy. By forging a

stable position in the tea market and effectively navigating the competitive process, Sri Lanka should outline its plan for competitiveness in the global tea market (Herath & Silva, 2011). Vithunan and Wijethunga (2021) examined the competitiveness of Sri Lankan tea by using a policy analysis matrix approach. However, the primary objective of this study was to conduct a thorough examination of the policy assistance for tea production in Sri Lanka from 2006 to 2019. The study's conclusions showed that policy initiatives are not protecting Sri Lanka's tea production (Vithunan & Wijethunga, 2021). However, this study makes no inferences regarding how Sri Lankan tea's competitiveness has evolved in the international market. The competitiveness of Sri Lankan tea on the global market has been assessed by Kithsiri, Jayamanna, and Abewickrama (2020). The constant market share model was used in this study to examine competitiveness and test the viability of applying the model for such purposes. The market growth effect, residual effect, and composition effect that affect the overall change in exported quantity to a particular country have received particular attention. According to the study's findings, Ceylon tea is found to be competitive in countries like Russia, Kuwait, Japan, Turkey, Germany, Australia, the United States, and India. Additionally, Azerbaijan, Iran, the United Kingdom, and Libya are discovered to have the potential to be competitors for Ceylon Tea (Kithsiri, Jayamanna, & Abewickrama, 2020). According to the findings of this study, it is very clear that Sri Lanka's tea exports have competitiveness in the markets mentioned above, such as Russia, Japan, and the United States. But this study has not examined how the competitiveness of Sri Lanka's tea exports changed over the periods of the identified export markets. Therefore, the findings of the study conducted by Kithsiri, Jayamanna, and Abewickrama also reveal the existing research gap in identifying the changes in Sri Lanka's competitiveness in tea exports in the world market.

The majority of studies on Sri Lanka's tea industry have concentrated on problems specific to the tea industry. Mujahid Hilal (2020) investigated the problems and tactics in the Sri Lankan tea industry. 53 interviews were performed for the study in Sri Lanka and India, and it was discovered that in order to maintain the sustainability of the Sri Lankan tea sector, it is essential to produce value-added tea products, support local brands on the international market, and advertise the goods abroad (Hilal, 2020). Even while the study identified a few elements that the Sri Lankan tea industry must contend with to remain competitive, it did not indicate how the sector's degree of competition has evolved.

In 2000, Ganewatta and Edward also investigated Sri Lanka's tea industry's economic problems and governmental initiatives. This study made clear that government policies for the tea sector must be consistent with the remedy of market failures if efficiency is to increase and international competitiveness is to be achieved (Ganewatta & Edwards, 2000). However, the study did not determine how competitive Sri Lankan tea is on the global market. Accordingly, there is a research shortage about the shift of Sri Lankan tea's competitiveness in the global market based on the volume of literature currently accessible on the Sri Lankan tea industry. By examining the competitiveness of Sri Lankan tea on the global market, this study seeks to narrow that gap.

Several publications have been evaluated in order to determine the best analytical techniques for assessing the competitiveness of Sri Lankan tea on the global market. The constant market share model used by Kithsiri, Jayamanna, and Abewickrama (2020) is appropriate for concentrating on the market growth effect, composition effect, and residual effect; nevertheless, it does not reflect how competitiveness has changed over time. Irshad and Arshad (2018) looked at Pakistani rice's ability to compete on the world market and its potential for export. This study is the first empirical attempt to identify prospective export destinations for Pakistani rice to 144 countries between 2003 and 2016 utilizing a panel-gravity approach and the PPML technique (Irshad, Xin, & Arshad, 2018). This study employed the Revealed Comparative Advantage (RCA) competitive index developed by Balasa (1965) and Vollrath (1991) to assess the export competitiveness of 10 significant rice exporters in the worldwide market.

The competitiveness of Knowledge Intensive Business Services (KIBS) in Singapore and Hong Kong was studied by Deng (2016). To quantify the competitiveness of particular industries, this study's approach included the use of three indices: export market share, disclosed comparative advantage, and revealed comparative advantage (Deng, 2016). The Revealed Comparative Advantage (RCA) competitive index was thus emphasized in the literature review as a useful tool for assessing the competitiveness of Sri Lankan tea on the global market.

According to Jackman, Lorde, Lowe, and Alleyne, the theory of comparative advantage is undoubtedly one of the most crucial ideas in the study of international trade, and it is frequently used to assess trade and export specialization patterns (Jackman, Lorde, Lowe, & Alleyne, 2011). The Heckscher-Olin (HO) theory and the Ricardian theory are two significant conventional trade theories that address comparative advantage. According to the Ricardian theory, countries with different relative production costs have a competitive advantage over one another. Instead, the HO hypothesis postulates that country advantages result from variations in factor pricing between nations. According to the HO theory, a country's comparative advantage is determined by its relative factor scarcity, meaning a country will export products that use its abundant and inexpensive element(s) of production and import products that use its scarce factor(s) of production to obtain comparative advantage.

Overall, the Ricardian Theory, proposed by David Ricardo, suggests that countries should specialize in producing goods in which they have a comparative advantage, even if they can produce all goods more efficiently than other countries. The comparative advantage theory, a refinement of the Ricardian theory, states that countries should specialize in producing goods where they have the lowest opportunity cost. The Heckscher-Ohlin Theory emphasizes the role of factor endowments, particularly labour and capital, in determining comparative advantage. According to this theory, countries will export goods that intensively use their abundant factors of production and import goods that use their scarce factors of production. Literature confirms that Sri Lanka has favourable geographical conditions, such as a suitable climate, altitude, and soil for tea cultivation. In the case of Sri Lanka's tea, based on its comparative advantage, Sri Lanka should focus on producing tea because it can produce it at a lower opportunity cost compared to other countries. Furthermore, Sri Lanka has a relatively abundant labour force compared to capital, which aligns with the labour-intensive nature of tea cultivation and processing. In summary, these economic theories collectively suggest that Sri Lanka's tea industry benefits from its comparative advantage, driven by factors such as favourable geography, historical expertise, and factor endowments. By specializing in tea production, Sri Lanka can enhance its competitiveness in the global market and capitalize on its strengths in the tea industry.

Literature shows that measuring comparative advantage is currently receiving significant attention from international experts. Because it is impossible to see relative pricing under an autarky, academics have created indices to gauge comparative advantage. The two main indexes that are being used are the Export Market Share (MS) and the Revealed Comparative Advantage (RCA). Since it was first suggested by Balassa (Balassa, 1965), RCA has been regularly used to assess comparative advantage, despite several drawbacks.

According to Greenaway & Milner, one problem is that the Balassa index of revealed comparative advantage is biased from the perspective that it just takes into account exports and ignores the influence of imports and, as such, implies possible over or underestimation of any underlying comparative advantage or disadvantage (Greenaway & Milner, 1993). In addition, there is an asymmetry problem. Since the 1980s, RCA index has been expanded and changed by various academics, including Balassa, in order to provide a more thorough and objective measuring approach. For instance, Relative Trade Advantage index - RTA (Vollrath, 1991), Net Export Revealed Comparative Advantage index - NXRCA (Balassa, B., 1989), and Revealed Export Advantage index - RXA (Esterhuizen & Rooyen, 2010) can be found. According to Kang, RTA appeared to be symmetrical and objective, making it more valid and acceptable for determining comparative advantage (Kang, 2014).

Thus, this research intends to utilize Market Share, RCA, and RTA indices when analyzing the competitiveness of Sri Lankan tea in the global market.

3. METHODOLOGY

This study is aimed at exploring the competitiveness of Sri Lanka's tea exports in the international market over time. Furthermore, the present study specifically attempts to achieve the following specific objectives:

To examine the relative contribution of Sri Lanka's tea exports to the international market.

To identify the changes of the average price of Sri Lanka's tea in the international market.

To assess the level of competitiveness of Sri Lanka's tea in the international market.

This research is based on secondary data for the time period spanning from 2002 to 2021. Data were extracted from TRADE MAP database that includes trade statistics for international business development. This study utilized data for the HS codes of headings 0902; Tea, whether or not flavoured. Table 01 projects the variables for which data were extracted.

Table 01: Summery of Variables

HS Code	Variable	Scale	Time Period
0902: Tea, whether or flavoured	Exported Quantity	Tons	2002 – 2021
0902: Tea, whether or flavoured	Exported Value	US Dollar Thousands	2002 – 2021
Total All Products	Exported Value	US Dollar Thousands	2002 – 2021

It is important to note that this study covers only the period from 2002 to 2021. When deciding the time period for the study, the availability of data was a concern. This time period encompasses nearly two decades, allowing for a comprehensive analysis of trends, fluctuations, and long-term patterns in the Sri Lankan tea industry. Furthermore, the selected time periods cover the global financial crisis (2007–2009) and the European sovereign debt crisis (2010–2012), which can influence the patterns of global tea exports. However, the selected time period is not enough to provide implications for the changes in the competitiveness of Sri Lankan tea due to the COVID-19 pandemic and the Russia-Ukraine war since it limits itself to the 2002–2021 period.

The review of the literature explored the possible techniques to assess the changes in the competitiveness of Sri Lanka's tea exports. This study has calculated market share (MS) to examine the relative contribution of a country's tea exports to the overall volume or value of tea traded internationally within a specified period. Furthermore, it projects how Sri Lanka's market share for tea exports has changed over time.

To identify the changes in the average price of Sri Lanka's tea in the international market, this study has calculated the export unit price (EUP). Monitoring changes in the tea export unit price over time can provide insights into market dynamics, such as fluctuations in demand, changes in consumer preferences, shifts in production costs, currency exchange rate movements, and variations in quality and grades of tea being traded. Additionally, the unit price can vary depending on factors such as the type of tea, its origin, its quality, and market conditions in importing countries.

Furthermore, this study has calculated the Revealed Comparative Advantage (RCA) and Relative Trade Advantage (RTA)I indexes to assess the level of competitiveness of Sri Lanka's tea exports in the international market. Both RCA and RTA indexes provide valuable insights into a country's export specialization and comparative advantage, helping policymakers, researchers, and businesses understand patterns of trade and identify opportunities for growth and diversification in international trade. The content below provides an overview of the formulas utilized for calculating MS, EUP, RCA, and RTA.

Export Market Share (MS) monitors a country's export performance compared with the total world's exports. The index for country i commodity j is calculated as follows.

$$MS_{ij} = \frac{X_{ij}}{X_{wj}} \quad (1)$$

Where: X_{ij} - country i's exports of commodity j; X_{wj} - world exports of commodity j; MS_{ij} - export market share of country i in commodity j. The greater value of the index indicates stronger competitiveness of country i in the commodity j. The value of MS ranges from 0 to 1.

The export unit price is measured using the total export value divided by the total quantity of exports. The export unit price for country i commodity j is calculated as follows;

$$EUP_{ij} = \frac{X_{ijt}}{QX_{ijt}} \quad (2)$$

Where, EUP_{ij} – country i's export unit price of commodity j; X_{ijt} – country i's export value of commodity j at time t; QX_{ijt} - country i's export quantity of commodity j at time t.

RCA index, which is measured by the product's share in the country's exports in relation to its share in the world trade. The index for country i commodity j is calculated as:

$$RCA_{ijt} = \frac{(X_{ijt})/(\Sigma_i X_{ijt})}{(\Sigma_j X_{ijt})/(\Sigma_i \Sigma_j X_{ijt})} \quad (3)$$

Where, RCAijt - country i's revealed comparative advantage of commodity j at time t, and i, j, and t refer to country i, product j, and time t, respectively. According to Hinloopen and Marrewijk (2001), the RCA value can be classified into four classes. Class 1: $0 < RCAij \leq 1$ are countries without a comparative advantage; Class 2: $1 < RCAij \leq 2$ are countries with a weak comparative advantage; Class 3: $2 < RCAij \leq 4$ are countries with a medium comparative advantage; and Class 4: $RCAij > 4$ are countries with a strong comparative advantage (Hinloopen & Marrewijk, 2001).

Relative Trade Advantage (RTA) index, which can be defined as the differences between RCA and the Revealed Import Advantage (RIA), is used to address the issue of asymmetry.

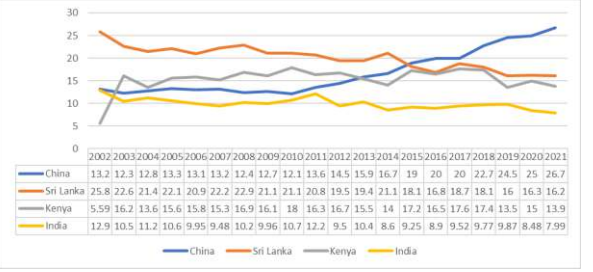
$$RTA_{ijt} = \frac{(X_{ijt})/(\Sigma_i X_{ijt})}{(\Sigma_j X_{ijt})/(\Sigma_i \Sigma_j X_{ijt})} - \frac{(M_{ijt})/(\Sigma_i M_{ijt})}{(\Sigma_j M_{ijt})/(\Sigma_i \Sigma_j M_{ijt})} \quad (4)$$

where variables are as defined in Equations (1) and (3), but M represents imports. Under this approach, positive values indicate a comparative advantage whereas negative values indicate comparative disadvantage.

Overall, this study examines how the competitiveness of Sri Lanka's tea exports changes in the international market. However, it does not provide an in-depth analysis of external factors, such as consumer preferences, trade policies, and global conditions, that can influence these changes in competitiveness. This can be identified as a limitation of the study.

4. RESULTS AND DISCUSSION

In the first stage of the analysis, the market share index (MS) was calculated for China, Sri Lanka, Kenya, and India. Figure 01 projects the results of MS index for the period 2002 -2021.



	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
China	13.2	12.3	12.8	13.3	13.1	13.2	12.4	12.7	12.1	13.6	14.5	15.9	16.7	19	20	20	22.7	24.5	25	26.7
Sri Lanka	25.8	22.6	21.4	22.1	20.9	22.2	22.9	21.1	21.1	20.8	19.5	19.4	21.1	18.1	16.8	18.7	18.1	16	16.3	16.2
Kenya	5.59	16.2	13.6	15.6	15.8	15.3	16.9	16.1	18	16.3	16.7	15.5	14	17.2	16.5	17.6	17.4	13.5	15	13.9
India	12.9	10.5	11.2	10.6	9.95	9.48	10.2	9.96	10.7	12.2	9.5	10.4	8.6	9.25	8.9	9.52	9.77	9.87	8.48	7.99

Figure 01: Values of MS Index for tea (%)

Source: Author's calculations

The largest market share for global tea exports in 2002 was held by Sri Lanka, with a 25.79 percent share. Sri Lanka's market share in the world's export of tea decreased significantly between 2002 and 2021, falling to 16.16%. As a result, Sri Lanka's once-dominant position in the world tea market has declined. There could be two factors influencing the market share losses for Sri Lanka. On the one hand, Sri Lanka saw a fall in its exports of tea to the international market. Additionally, there is a difference in the rate of growth between Sri Lankan and global tea exports. These two factors could lead to a decline in the relative position on a worldwide scale.

On the other hand, Kenya and China, two of the top exporters of tea, have seen a huge growth in market share. With a rise in market share from 13.15 to 26.7 percent, China now holds the greatest market share in the worldwide tea market. Kenya's market share increased significantly from 5.58 percent to 13.85 percent. India's market share has decreased from 12.86 percent to 7.989 percent; thus, it does not anticipate a consistent increase in that percentage.

Secondly, the fluctuation of the Sri Lankan tea export unit price is computed. The results of the variation in the export unit price of Sri Lankan tea on the global market between 2002 and 2021 are demonstrated in figure 02.

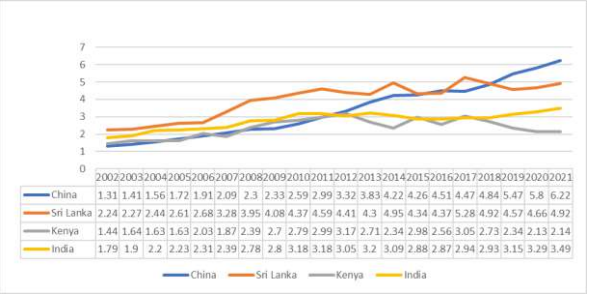


Figure 02: Fluctuations of the unit price of tea export
Source: Author's calculations

The highest unit price for tea exported to the international market in 2002 was obtained by Sri Lanka. The unit price of Sri Lankan tea has steadily increased since 2006, following a sluggish increase from 2002 to 2006. The export unit price's upward tendency, which was previously mentioned, could be influenced by a number of factors. 2009's unfavourable weather contributed to the rise in tea prices (United Nations, 2009). Although Sri Lankan tea's reputation and high quality helped to create higher global demand, the financial crisis of 2009/2008, and the Covid-19 pandemic had a detrimental influence on the tea market. Some of the government policies have also contributed to this unit price increase. The ban of glyphosate in the Sri Lankan tea sector is one of the major factors that might have contributed to this trend. Glyphosate had been used for weed control in Sri Lanka for a number of years, including on tea plantations. However, glyphosate was immediately banned in June 2015 as a result of a gazette notification. The yield has decreased by five to ten percent as a result of this decision (Bayer, 2022).

Although the price of a unit of tea exported from Sri Lanka has changed throughout time, the price of a unit of tea exported from China has dramatically increased. China had the lowest unit price for tea exports among the major competitors in 2002, but the highest unit price in 2021. The unit prices for tea exported from Kenya and India have varied greatly, but the unit price for Indian tea exports indicates a consistent upward tendency.

In the third stage, this study utilized Balassa's 1965 Revealed Comparative Advantage (RCA) technique to assess the competitiveness of Sri Lankan tea on the global market. The RCA index results are projected in figure 3.

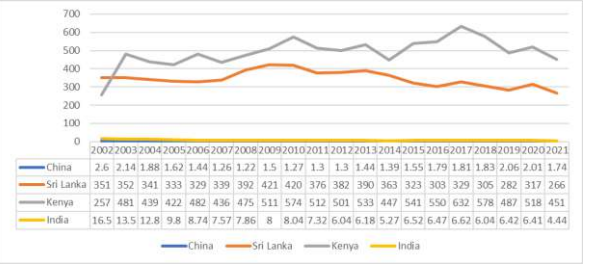


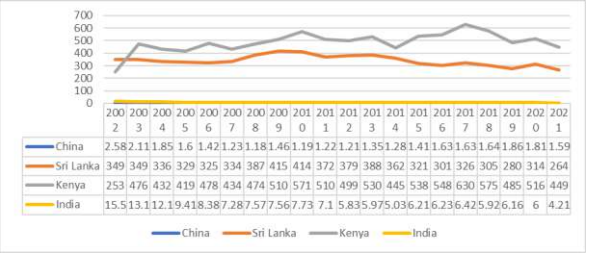
Figure 03: Values of RCA Index for Tea Exports
Source: Author's calculations

In accordance with Hinloopen and Marrewijk's (2001) classification of the RCA index, Sri Lanka can be categorized as a highly competitive tea exporting nation to the global market. Sri Lanka recorded 351 RCA values in 2002, making it the most competitive exporter on the global tea market. But over time, Sri Lanka has seen a decline in its level of competition in the global tea market. As a result, Sri Lanka's RCA value fell from 351 in 2002 to 266 in 2021. Numerous domestic factors could have contributed to this downward trend. Sri Lankan tea industry is mainly reliant on manual labour and uses extremely basic technologies. As a result, the industry deals with a number of problems with the availability and cost of labour. Furthermore, it has previously been demonstrated that Sri Lanka's tea industry has low productivity (Thushara, 2015). Additionally,

government initiatives like the prohibition of glyphosates and chemical fertilizers may have contributed to this decline in competitiveness.

Kenya can also be categorized into the highly competitive tea exporting category, and it has become the world highest competitive tea exporting country in the world surpassing Sri Lanka. Even though India is a competitive tea exporter, India does not project a considerable improvement of RCA value. Most interestingly, China can be categorized as a low competitive tea exporter in the world market in terms of the RCA index.

In the final step of the analysis, this study calculated the Revealed Trade Advantage (RTA) in order to determine if the chosen tea exporting countries have a comparative advantage or disadvantage for tea exports. Figure 04 projects the RTA index's outcomes.



	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
China	2.58	2.11	1.85	1.6	1.42	1.23	1.18	1.46	1.19	1.22	1.21	1.35	1.28	1.41	1.63	1.63	1.64	1.86	1.81	1.59
Sri Lanka	349	349	336	329	325	334	387	415	414	372	379	388	362	321	301	326	305	280	314	264
Kenya	253	476	432	419	478	434	474	510	571	510	499	530	445	538	548	630	575	485	516	449
India	15.5	13.1	12.1	9.41	8.38	7.28	7.57	7.56	7.73	7.1	5.83	5.97	5.03	6.21	6.23	6.42	5.92	6.16	6	4.21

Figure 04: Values of the RTA Index
Source: Author's calculations

The country has a comparative disadvantage for exporting tea if the RTA values are negative. For the entire period, Sri Lanka projected a comparative advantage for tea exports. Sri Lanka had the highest RTA value in 2002, but since then, it has been on the decline. This highlights how Sri Lankan tea exports are losing ground in terms of competitiveness. The RTA levels have, however, significantly improved in Kenya. However, beyond 2020, RTA shows a falling trend in both Kenya and Sri Lanka. This weakening competitiveness may have been caused by the Covid-19 epidemic. India and China have a comparative advantage when it comes to exporting tea, but they are not very competitive in the world market.

5. CONCLUSIONS

This study intended to determine the level of Sri Lankan tea exports' competitiveness on the global market. The three nations with the highest global tea exports—China, Kenya, and India—were chosen for this study for the sake of a straightforward comparison. In order to assess the competitiveness of tea exports on the global market, this study utilized four indices, including Export Market Share (MS), Export Unit Price (EUP), Revealed Comparative Advantage (RCA), and Revealed Trade Advantage (RTA).

Based on the findings of the study, it can be concluded that both the competitiveness and comparative advantage of Sri Lanka's tea exports have declined considerably over time. The negative changes in market share, revealed comparative advantage, and revealed trade advantage indices support this conclusion. Comparatively cheaper than Sri Lanka, Kenya supplies its exports of tea on the world market. As a result, Sri Lanka can eventually see a decline in market demand. Despite having strong performances in the global tea market, China and India's competitiveness and comparative advantage for exporting tea are diminishing. Kenya, however, is achieving great competitiveness in the global tea market while maintaining a lower export unit price. Furthermore, both the RCA and RTA indices have provided consistent results.

Based on these conclusions, this study comes up with certain policy implications. Cost-effective production techniques should be carefully considered by Sri Lankan tea producers in order to reduce the selling price relative to competing suppliers on the global market. Additionally, the government can help the local tea industry become more productive by offering some technical aid.

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DEPRESSION, ANXIETY, AND STRESS AMONG ALLIED HEALTH SCIENCES UNDERGRADUATES: A CROSS-SECTIONAL STUDY AT A DEFENCE UNIVERSITY IN SRI LANKA

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ABSTRACT

The mental health of university undergraduates is a critical concern globally, with challenges faced by students in unique academic environments. This study was conducted at General Sir John Kotelawala Defence University to assess the prevalence of mental health issues and identify associations with participant characteristics. A descriptive cross-sectional study involving 640 allied health sciences undergraduates was performed. The Depression, Anxiety, and Stress Scale-21 Items (DASS-21) was utilized for evaluation. Statistical analysis was performed with SPSS 23.0, and associations were explored using Spearman's correlation and Pearson's chi-square tests. Ethical approval was obtained, ensuring participant confidentiality and informed consent. The study revealed mild to extremely severe symptoms of depression (35.1%), anxiety (40.5%), and stress (27.7%) among the participants. Strong positive relationships were identified between depression and anxiety (r=0.707, p=.000), depression and stress (r=0.722, p=.000), and anxiety and stress (r=0.658, p=.000). Significant associations were found between mental health levels and participants currently receiving medical treatments and those with a history of psychological treatments. While one-third of the participants exhibited concerning levels of mental health symptoms, our study indicated comparatively lower rates than did previous research in Sri Lanka. The findings highlight the need to enhance mental health support and accessibility of services for university undergraduates. The study contributes valuable insights for future research and interventions, emphasizing the unique challenges faced by students in a defence university setting.

KEYWORDS: *Depression, Anxiety, Stress, Undergraduates, Sri Lanka*

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1. INTRODUCTION

University life marks a critical phase marked by significant lifestyle changes, new social dynamics, and potential stressors for undergraduates (Sravani et al., 2018). The challenges are intensified for those living away from home for the first time, who often lack effective coping mechanisms (Freire et al., 2020), leading to a high prevalence of mental health issues such as depression, anxiety, and stress during this transitional period (Kerebih et al., 2017; Ramón-Arbués et al., 2020). Globally, 12–50% of college students reportedly present at least one diagnostic criterion for such mental disorders (Bruffaerts et al., 2018).

Depression among undergraduate students is a significant concern that impacts their well-being and academic performance (Deng et al., 2022). Factors such as family stress, academic stress, and the transition from high school to university can contribute to depression among students, affecting their academic performance (Deng et al., 2022; Nurmina et al., 2021). Previous studies conducted in Sri Lanka have indicated a high prevalence of depressive symptoms among Sri Lankan undergraduates (Amarasuriya et al., 2015; Dahanayake et al., 2021; De Zoysa et al., 2022). A recent study conducted at the University of Jaffna, Sri Lanka, reported that a major depressive disorder was experienced by 31% of university students, 70% of whom reported some form of depression ranging from mild to severe (Wickramasinghe et al., 2023). Studies have also highlighted the high prevalence of depression among specific groups of undergraduate students, such as those in medical (Asra et al., 2022), nursing (Rosenthal et al., 2021), physiotherapy (Yakasai et al., 2022), pharmacy (Shangraw et al., 2021) and dental (Freitas et al., 2022) schools. Furthermore, research indicates that undergraduates may experience similar levels of depression as graduate students but are less likely to seek mental health services (Cooper et al., 2020).

Research indicates that a considerable portion of undergraduate students struggle with anxiety, with nursing students frequently encountering elevated levels of anxiety compared to their counterparts in other academic disciplines. (Walker, 2022). Additionally, there is an observed negative relationship between anxiety and academic performance, with higher anxiety levels correlating with lower grade point averages (GPAs)(Choudhury, 2022). A study among nursing undergraduates at the University of Peradeniya, Sri Lanka, revealed that 59.8% of the population had moderate to extremely severe levels of anxiety (Rathnayake and Ekanayaka, 2016).

Stress is a common issue among undergraduate students, affecting their academic performance and overall well-being. Various studies have identified key stressors and the impact of stress on undergraduates. Common stressors include the transition to university, academic pressure, lack of sleep, personal relationships, and poor coping skills (Ebenezer. C et al., 2020; Garett et al., 2017). The consequences of stress for students are significant, with adverse effects on their college experience and academic achievement (Morey and Taylor, 2019). Stress levels can vary among different student groups, with first-year students often facing substantial stress due to the challenges associated with change and increased responsibilities (Owusu, 2021). As revealed by a previous Sri Lankan epidemiological study, 39.8% of undergraduates are victims of stress (Kuruppuarachchi et al., 2014).

Recent literature has highlighted a significant prevalence of depression, anxiety, and stress among allied health sciences undergraduates, and those studies have consistently demonstrated that students in this field are at a greater risk for mental health issues than the general population is (Awotidebe et al., 2022; Nahas et al., 2019; Ramón-Arbués et al., 2020). Furthermore, existing studies in Sri Lanka have focused on allied health undergraduates, revealing a high prevalence and positive correlations between these mental health variables (Ilankoon and Warnakulasooriya, 2014; Rathnayake and Ekanayaka, 2016).

Despite ample research on assessing depression, anxiety, and stress among Allied Health Science undergraduates globally, few studies have been conducted in Sri Lanka, especially in the context of a defence university. General Sir John Kotelawala Defence University (KDU), which is distinct in its military setting, emphasizes discipline, commitment to service, and academic excellence. This study aimed to address this gap in the literature by assessing depression, anxiety, and stress levels among undergraduates of the Faculty of Allied Health Sciences (FAHS), KDU. Additionally, the findings from this study may inform university policies regarding mental health support for students and contribute to broader university and national policies aimed at addressing mental health issues among undergraduates.

Research Questions:

1. What are the prevalence rates of depression, anxiety, and stress among allied health sciences undergraduates at the FAHS, KDU?
2. How do demographic factors such as gender, academic year, and degree course relate to levels of depression, anxiety, and stress among allied health sciences undergraduates at the FAHS, KDU?
3. Are there significant correlations between depression, anxiety, and stress levels among allied health sciences undergraduates at the FAHS, KDU?

2. METHODOLOGY

Study Design and Participants

A descriptive cross-sectional study was conducted at the FAHS, KDU, Sri Lanka. The study included all allied health sciences undergraduates (n=640) at FAHS, representing diverse disciplines such as nursing and midwifery, physiotherapy, medical laboratory sciences (MLS), pharmacy, radiotherapy, and radiography.

Data collection

Data collection took place in the middle of the semester (from March to April 2020) to ensure a consistent academic environment for all participants. This study utilized the self-reported (0-3), 21-item Depression, Anxiety, and Stress Scale (DASS-21) for measuring negative emotional states. The DASS-21, which has been validated in Sri Lanka, has reported scores of 0.83, 0.76 and 0.80 for depression, anxiety and stress, respectively (Rekha, 2012). The severity of depression, anxiety, and stress (mild, moderate, severe, or extremely severe) of the participants was measured according to the cut-offs given on the scale (Table 1). Participant characteristics, including sex, academic year, degree course, current medical treatments, and history of psychological treatments, were also collected.

Table 1 Cut-off values for depression, anxiety, and stress according to the DASS-21

Severity levels	Depression	Anxiety	Stress
Normal	0-9	0-7	0-14
Mild	10-13	8-9	15-18
Moderate	14-20	10-14	19-25
Severe	21-27	15-19	26-33
Extremely severe	28+	20+	34+

Statistical analysis

The data were analysed using SPSS version 23.0. Descriptive statistics were employed to summarize participant characteristics. The Shapiro–Wilk test confirmed that the distributions of depression, anxiety, and stress scores were not normal ($p<0.005$). Therefore, Spearman's correlation test was used to examine relationships between depression, anxiety, and stress. Pearson's chi-square test was used to explore associations between categorical variables (e.g., gender, academic year, degree course) and mental health levels. The significance level was set at < 0.05.

Ethical Consideration

The study received ethical approval from the Ethics Review Committee (RP/S/2020/15), Faculty of Medicine, KDU, Sri Lanka. Institutional approval was obtained from the Vice-Chancellor, KDU, and the Dean, FAHS, KDU. Informed consent was obtained online from participants, who emphasized voluntary participation and the right to withdraw at any time.

3. RESULTS

Participant Characteristics

Of the total population of 679 undergraduates, 640 (94.25%) responded to the study. Most of the participants were females (75.8%) or were Sinhalese (94.4%). Nursing undergraduates constituted the majority (24.2%) (Table 2).

Table 2 Descriptive statistics for participant characteristics (n = 640)

Demographic Characteristics		Frequency	Percentage %
Gender	Male	155	24.2
	Female	485	75.8
Ethnicity	Sinhala	604	94.4
	Tamil	19	3.0
	Muslim	15	2.3
	Burgher	02	0.3
Academic Year	First-year	162	25.3
	Second year	155	24.2
	Third year	153	23.9
	Fourth year	170	26.6
Degree course	Nursing	156	24.2
	Physiotherapy	141	22.0
	MLS	128	20.0
	Pharmacy	113	17.7
	Radiography	60	9.4
	Radiotherapy	43	6.7

Study Measurements

The mean scores for depression, anxiety, and stress were 8.11±7.857, 6.93±6.764, and 11.45±8.199, respectively. Mild to extremely severe symptoms were observed in 35.1% of participants with depression, 40.5% with anxiety, and 27.7% with stress (Table 3).

Table 3 Distribution of depression, anxiety, and stress levels among the respondents

Category	Subcategory	Frequency	%	Mean ±SD
Depression	No Depression	416	64.9%	3.47±2.88
	Mild	105	16.4%	11.79±1.73
	Moderate	76	11.9%	17.21±2.92
	Severe	26	4.1%	24.23±2.36
	Extremely severe	17	2.7%	33.76±4.24
Anxiety	No Anxiety	381	59.5%	2.43±2.21
	Mild	58	9.1%	8.10±0.58
	Moderate	132	20.6%	11.95±1.66
	Severe	30	4.7%	16.60±0.93
	Extremely severe	39	6.1%	24.67±4.48
Stress	No stress	463	72.3%	7.51±4.79
	Mild	70	10.9%	16.71±0.97
	Moderate	63	9.8%	21.40±1.89
	Severe	34	5.3%	28.06±2.29
	Extremely severe	10	1.6%	38.00±3.40

Relationships among Depression, Anxiety, and Stress

A significant strong positive relationship was identified between depression and anxiety (r=0.707, p=.000), depression and stress (r=0.722, p=.000), and anxiety and stress (r=0.658, p=.000).

Table 4: Relationships between Depression, Anxiety, and Stress

Relationship	Correlation Coefficient	p value
Depression and Anxiety	0.707	0.000
Depression and Stress	0.722	0.000
Anxiety and Stress	0.658	0.000

Associations of participant characteristics

A statistically significant association was found

between depression level and Degree course (G2=34.328, p=0.023). Participants currently receiving medical treatment showed statistically significant associations with depression (p=0.002), anxiety (p=0.000), and stress (p=0.002). A history of psychological treatment was significantly associated with anxiety (p=0.009) and stress (p=0.040) (Table 5).

Table 5 Associations of participant characteristics with depression, anxiety, and stress

Characteristic	Category	Frequency	p value		
			Depression	Anxiety	Stress
Gender	Male Female	155 485	0.151	0.733	0.649
Academic year	First Year Second Year Third Year Fourth Year	162 155 153 170	0.779	0.077	0.967
Degree course	Nursing Physiotherapy MLS Pharmacy Radiography Radiotherapy	156 141 128 113 60 43	0.023*	0.367	0.384
Currently under Medical treatments	Yes No	67 573	0.002*	0.000*	0.002*
History of psychological treatments	Yes No	71 569	0.152	0.009*	0.040*

* At a significance level of 0.05

4. DISCUSSION

The findings of this study elaborate on the prevalence of depression, anxiety, and stress among undergraduates in a defence university in Sri Lanka. In interpreting these results, it is crucial to contextualize them in the broader landscape of mental health research among university students.

a) Prevalence of Mental Health Symptoms

The observed prevalence of mild to extremely severe symptoms of depression (35.1%), anxiety (40.5%), and stress (27.7%) among allied health sciences undergraduates at the General Sir John Kotelawala Defence University (KDU) raises important questions. Similarly, a study conducted in Vietnam (Pham et al., 2019) highlighted a 36.4% prevalence of depression among health sciences students. Additionally, Mahotra et al., 2021 reported notable levels of depression, anxiety, and stress among health science students in Nepal, with rates of 43%, 33%, and 29%, respectively. Although the rates from the current study are concerning, as with research conducted globally, they appear to be lower than those reported in previous studies conducted among similar populations in Sri Lanka (Ilankoon and Warnakulasooriya, 2014; Rathnayake and Ekanayaka, 2016; Wickramasinghe et al., 2023). This difference may be attributed to recent reforms in nursing education in Sri Lanka, including enhanced graduate education, curriculum evolution, and improved healthcare facilities (Jayasekara and Amarasekara, 2015; Kumara and Sudusinghe, 2021). Furthermore, the distinct academic and administrative environment of a defence university could contribute to this variation. However, further research is warranted to explore these differences comprehensively. Furthermore, it is crucial to acknowledge that challenges persist, demanding continued attention to students' mental well-being (Nair and Otaki, 2021).

b) Relationship between mental health symptoms

The identified strong positive relationships between depression and anxiety, depression, and stress, as well as between anxiety and stress (ranging from 0.658 to 0.722), underscore the interconnected nature of these mental health dimensions. This correlation suggests that undergraduates at FAHS - KDU are more likely to experience multiple symptoms simultaneously. This intricate relationship requires a

holistic approach to mental health interventions, recognizing the interdependence of depression, anxiety, and stress.

c) Associations with participant characteristics

The association between depression levels and disease severity reveals an intriguing finding. Variances in curricula and academic demands among different courses may contribute to diverse stressors, influencing mental health outcomes. Understanding these nuances is pivotal for tailoring support mechanisms for students in specific degree programs. The significant associations between participants currently receiving medical treatment and those with a history of psychological treatment highlight the impact of existing health conditions on mental health. This emphasizes the need for integrated healthcare models within educational institutions, ensuring that mental health support aligns with ongoing medical treatments (Lindsay et al., 2022).

d) Implications for mental health support

The identified mental health challenges among allied health sciences undergraduates underscore the imperative need for strong mental health support within the university environment. Frequent psychological assessments, accessible mental health services, and targeted interventions are essential components in fostering a supportive atmosphere. By proactively addressing mental health concerns, educational institutions can contribute to enhanced academic performance, personal development, and overall well-being (Pehlivan et al., 2020).

Limitations of the study

The study sample was restricted to FAHS, KDU, potentially limiting the generalizability of the results to other populations or institutions. Additionally, the use of self-report measures introduces the possibility of biases and inaccuracies. Future research should aim for larger, more diverse samples and consider incorporating multiple assessment techniques to enhance the robustness of the findings.

5. CONCLUSION

In conclusion, this study provides valuable insights into the mental health profile of allied health sciences undergraduates at FAHS, KDU. Although the prevalence of symptoms is noteworthy, the relatively lower rates than those reported in previous research in Sri Lanka suggest potential positive impacts from recent educational reforms. The findings emphasize the complex interplay between depression, anxiety, and stress, urging tailored interventions and continuous mental health support. Addressing mental health challenges among university students is paramount for cultivating a resilient and thriving academic community.

Author Contributions

DKJP, KS, VBJP, and SDHD were involved in project implementation, data collection, analysis, and preparation of the manuscript. CKWG and NFJF were involved in the conceptualization, design, project implementation, analysis, and correction of the draft.

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Competing Interests

The authors declare that they have no competing interests.

Data sharing statement

The datasets generated and analysed in the current study will not be shared publicly to preserve the privacy and confidentiality of the participants. However, the datasets from this study are available from the corresponding author upon reasonable request.

6. ACKNOWLEDGEMENTS

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TOWARDS A PARADIGM SHIFT WITH NEURO-ENTREPRENEURSHIP EDUCATION: A LESSON FOR THE DEVELOPING ASIAN NATIONS

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ABSTRACT

The field of neuro-entrepreneurship explores the specific characteristics that drive entrepreneurs' decisions and contribute to their success. Recent advancements in neuroscience offer a new way to understand how entrepreneurs think and behave. This understanding has led to a shift in entrepreneurial education, with a focus on integrating neuroscientific techniques. However, research in neuro-entrepreneurship is still fragmented, and there is a lack of comprehensive literature reviews. We are presenting a thorough review to address this gap and emphasize the urgent need for developing countries in South and South East Asia to incorporate neuroscientific techniques into entrepreneurial education, starting from the school level. The current entrepreneurial education in Sri Lanka suppresses the innovation and creativity of aspiring entrepreneurs, leading to a high demand for traditional practices. Integrating neuroscientific techniques into entrepreneurial education at all levels can help foster successful and productive entrepreneurs. This also emphasizes how experiments and neuroscientific techniques can improve entrepreneurial theories. This calls for a significant change in entrepreneurship education, aiming to cultivate a comprehensive entrepreneurial mindset in developing Asian nations.

KEYWORDS: *Cognitive Neuroscience, Entrepreneurial Behavior & Mindset, Neuro-entrepreneurship Education, PRISMA*

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1. INTRODUCTION

Entrepreneurship is widely seen as a driver of economic growth. However, in developing countries, there is uncertainty about whether entrepreneurship education effectively equips individuals to independently implement viable business ideas alongside theoretical knowledge (Hanuun et al., 2023). Recent research has explored the use of neuroscientific techniques to study entrepreneurial skills, mindsets, and behaviors (Massaro et al., 2023). The Institute of Growth Concept (2016) suggests that incorporating neuroscientific techniques into entrepreneurial education at all levels can help cultivate successful entrepreneurs.

Neuroentrepreneurship is a new research field in which many developed countries invest human capital to study emerging mental health challenges and their crucial role in policy implementation (Sharma et al., 2021). The study of entrepreneurship is a complex science influenced by various perspectives and intervening factors. The psychology of entrepreneurship utilizes cognitive and behavioral sciences to examine entrepreneurial behavior (Pidduck et al., 2023). The field of cognitive science explores heuristic ideas and the entrepreneurial mindset to identify cognitive processes that enable quicker and more efficient decision-making (Gilbert-Saad et al., 2023). An individual with an entrepreneurial mindset can create value by recognizing and seizing opportunities, making decisions with incomplete information, and maintaining flexibility and resilience in complex and challenging circumstances (Joshua et al., 2021).

Recently, there has been a significant increase in efforts to understand the factors contributing to entrepreneurial success. This is evident through a rise in academic research, publications, and a thriving business consultancy sector catering to entrepreneurs (Elkaim, 2020; Lesonsky, 2019). While studies recognize that a Management Mindset and an Entrepreneurial Mindset complement each other, they also emphasize that transitioning from one to the other can lead to a sustainable competitive advantage (Wright et al., 2000). Behavioural analysis places a strong emphasis on how entrepreneurs make decisions regarding their competence and behaviour. Entrepreneurial behaviour is influenced by traits such as dynamism, leadership, risk-taking ability, adaptability, and internal drive (Pidduck et al., 2023).

The different types of entrepreneurial opportunities such as creative, exploratory, allocative, and imitation are supported by specific attributes (Chrysikou, 2014; Hunter, 2013; Sarasvathy et al., 2010). When examining entrepreneurship, organizational characteristics like innovation, development, and expansion are also taken into consideration (Cucino et al., 2021). Further, there are factors that prevent individuals from becoming entrepreneurs; cognitive bias can affect an individual's risk assessment and decision-making, causing them to view entrepreneurship as too risky (Thomas, 2018). Neurological differences can impact traits like risk tolerance, creativity, and resilience, which are vital for entrepreneurship (Massaro et al., 2023). Furthermore, the current education system in Sri Lanka suppresses the innovation and creativity of undergraduates, leading to a high demand for government jobs or brain drain (Fernando, 2019).

2. EVOLUTION OF THE CONCEPT

The emerging field of neuro-entrepreneurship education combines cognitive neuroscience and entrepreneurial education (Korpysa, 2020). Researchers use tools such as Electroencephalogram (EEG), Functional Magnetic Resonance Imaging (FMRI), eye tracking, and Galvanic Skin Response to investigate the neural underpinnings of entrepreneurial decision-making. In their work, Korpysa (2020) introduces the concept of neuro-entrepreneurship and argues for the application of neuroscience in studying entrepreneurial processes.

A pictorial summary of the evolution of neuro-entrepreneurship is created using techniques from cognitive neuroscience, along with sub-branches of entrepreneurial education and cognitive and behavioral science. Figure 1 illustrates the interdisciplinary approach to entrepreneurship.

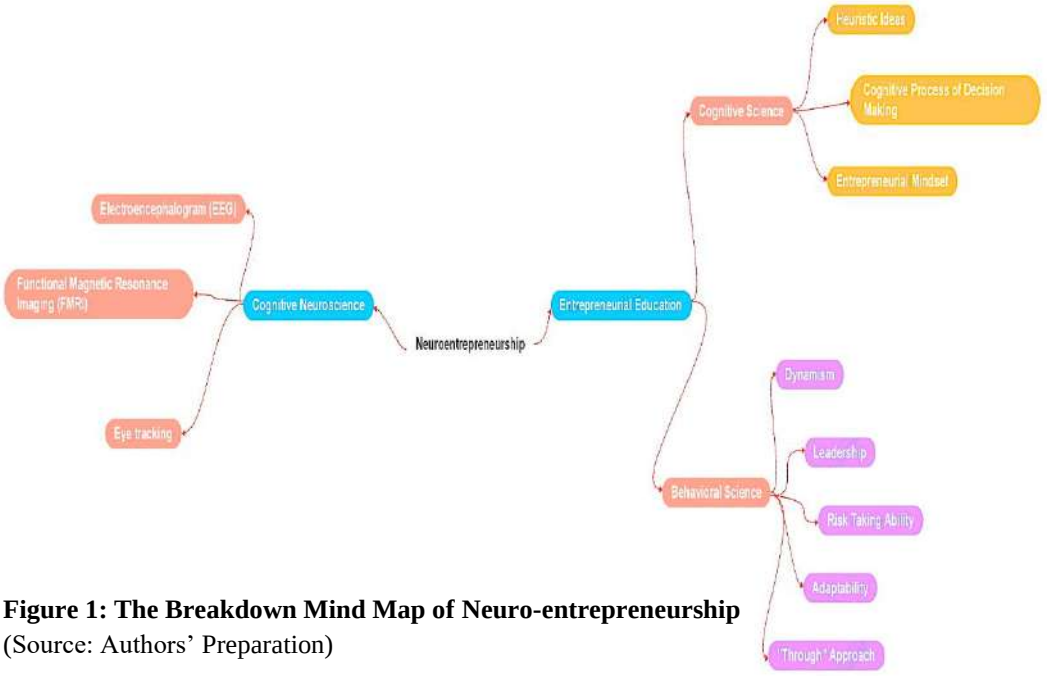

Figure 1: The Breakdown Mind Map of Neuro-entrepreneurship
(Source: Authors' Preparation)

The study by Zaro et al. (2016) utilized cognitive brain mapping (CBM), a quantitative research tool, along with EEG readings. EEG recordings were taken while fourteen male participants, including both experienced business owners and non-entrepreneurs, made decisions. The study analyzed the flow of information across different brain areas using entropy correlation calculations, providing insights into the cognitive processes associated with entrepreneurship. The small sample size was justified, highlighting the potential for significant findings in neuroscience research through consistent brain activation patterns at the individual participant level.

The use of cerebral mapping allowed for the analysis of network structures related to entrepreneurial decision-making, creating Cognitive Brain Maps through the computation of entropy values.

The Massaro et al. (2023) uses fMRI to measure the traits of entrepreneurs through various experimental designs. The "pure insertion" assumption is used to compare brain activity in response to different tasks through cognitive subtraction. Additionally, cognitive conjunction evaluates common brain regions between different cognitive process stages. The parametric design treats the variable of interest as continuous and examines correlations between changes in the variable and alterations in brain activity.

Functional integration models show promise for understanding social cognition, leadership dynamics, and entrepreneurship by examining different brain regions while they are interacting during activities and while they are at rest.

In a study conducted by Kaminskiene et al. (2023), an eye-tracking method was used to research entrepreneurship education. After reviewing 505 papers, 105 were found to be relevant. Eye-tracking systems, from lab to mobile, measured pupil size, fixations, and saccades to gain insights into learning processes and attention distribution in both controlled and uncontrolled environments. By considering the perspectives of teachers and students, this approach enhances established qualitative and quantitative methodologies in entrepreneurship education research.

3. 'THROUGH' APPROACH TO ENTREPRENEURIAL EDUCATION

The study's research problem addresses the lack of investigation and integration of neuroscientific

methods as a comprehensive approach in the context of entrepreneurship education in Asian countries (Ghina et al., 2017). Although the traditional view of entrepreneurship has historically placed more emphasis on behavioral and psychological aspects, recent advancements in neuroscience offer a novel way to comprehend the thoughts and actions of entrepreneurs. The study highlights a theoretical and practical gap in the development of a new paradigm for entrepreneurial education due to the insufficient use of neuroscientific methodologies in entrepreneurship education in developing Asian nations.

According to Cucino et al. (2021), Asian nations are lagging behind in integrating neuroscientific methods into entrepreneurial education. Specifically, the application of neuroscience in entrepreneurship remains a subject of debate in Sri Lanka (Jauk & Kanske, 2021). Empirical studies by Cucino et al. (2021), Jauk & Kanske (2021), and Jeyaseelan et al. (2023) have revealed the significant lack of neuroscientific education, especially in entrepreneurship, in developing Asian countries.

The majority of current instructional strategies are based on conventional wisdom, which overlooks the potential benefits offered by neuroscientific understandings for better understanding and fostering an entrepreneurial attitude and behavior. The lack of research in this field creates a significant knowledge gap, making it challenging to fully grasp how neuroscientific methods could be utilized in local entrepreneurship education (Cucino et al., 2021; Jauk & Kanske, 2021).

The study indicates that there is a significant gap in Asian entrepreneurship education regarding the use of neuroscientific techniques and experimental methodologies. The absence of experimental applications, such as transcranial magnetic stimulations (TMS) and control tasks like the BART risk-taking game, hinders the exploration of brain and psychological behaviors essential for a complete understanding of neuro-entrepreneurship. The research emphasizes the necessity for a shift in the paradigm of entrepreneurship education systems in Asian countries. To foster a comprehensive entrepreneurial mindset, the traditional "about" or "for" approaches should be replaced by a more dynamic and practical "through" approach that integrates neuroscientific strategies at the educational level.

The research issue that has been identified has significant implications for academics and policymakers in Asian nations. Addressing the gap in the theoretical and practical applications of neuroscientific tools in entrepreneurship education can lead to the development of a more efficient and comprehensive paradigm. This shift is crucial for fostering entrepreneurial skills, mentality, and behavior that align with the evolving business and innovation landscape of the twenty-first century.

4. RESEARCH OBJECTIVES

This study seeks to connect theory with practice by creating a new framework that utilizes insights from neuroscience to improve the comprehension and development of entrepreneurial attitudes and behaviors. We propose a model for incorporating neuroscientific methods into entrepreneurship education in developing Asian countries, with a focus on addressing specific gaps.

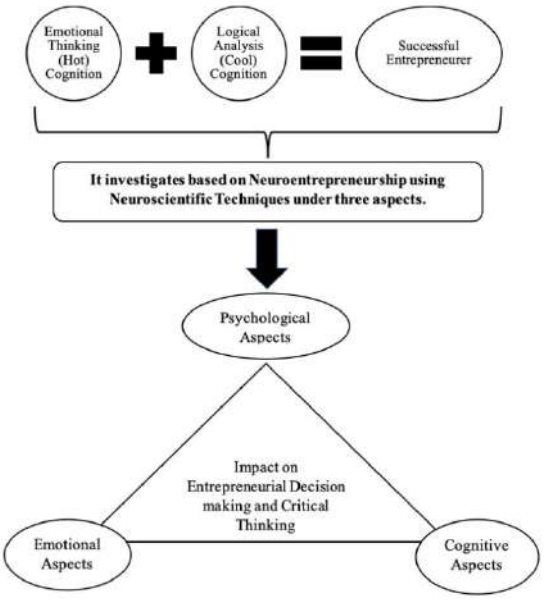

Figure 2: Visualizing the transformation of the entrepreneurship into neuro-entrepreneurship (Source: Authors' preparation)

The study aims to provide insights into the implications of addressing the theoretical and practical gaps in neuro-entrepreneurship education for academia and policymakers. It emphasizes the potential benefits of a paradigm shift to foster entrepreneurial skills, mentality, and behavior that align with the evolving business and innovation landscape. The study also seeks to contribute to the advancement of neuro-entrepreneurship education by offering practical recommendations and a holistic framework that addresses the identified gaps and supports the development of more effective and relevant educational paradigms in the context of developing Asian nations.

The literature on neuro-entrepreneurship examines the differences in brain activity between entrepreneurs and non-entrepreneurs using various neuroscientific techniques. According to Lawrence et al. (2008), successful entrepreneurs engage in both emotional (hot) thinking and logical analysis (cool). Frontal lobes regulate neural activity, which occurs in multiple parts of the brain. Stanton et al. (2008) used neuroeconomics methods to investigate the rationality of entrepreneurs' decisions. Zald et al. (2008) found that entrepreneurs, similar to risk-takers, have increased dopamine receptor density in their brains. Heydari et al. (2020) describes entrepreneurial cognition as the cognitive structures that influence assessments, judgments, and decisions in opportunity evaluation and venture formation. They draw on the literature on social cognition and cognitive psychology to understand the mental processes behind entrepreneurial activity.

Heydari et al. (2020) also suggests three important elements for the growth of the field of neuro-entrepreneurship: rejecting the computational theory of the brain, emphasizing outcomes like mirror neurons, empathy, semantic simulation, dopamine system, and habits, and replacing the conventional Turing machine with new tools.

The study by Heydari et al. (2020) delves into the mental processes involved in entrepreneurial learning, exploring aspects such as purpose, convictions, and complex knowledge systems. It highlights the importance of technical skills, interdisciplinary collaboration, and an understanding of perceptions, causes, and effects. According to Heydari et al. (2020), the study introduces a model that encompasses temporal, neurological, and cognitive dimensions, suggesting that examining cognitive processes at various levels is crucial for comprehending entrepreneurial behavior.

Simon (1997) is recognized as the first to analyze three levels of cognition-related phenomena: the external level, which focuses on observable behavior; the internal level, which delves into attitudes, beliefs, and intentions; and the deep level, which examines neurological processes (Heydari et al., 2020). Recent years have seen a significant increase in global entrepreneurship research across diverse fields, acknowledging the vital role of entrepreneurship in the economic and social development of nations (Shane, 2000; Davidsson, 2016).

The impact of entrepreneurship extends beyond market innovation and economic growth to encompass job creation, contributing to higher employment levels (Shane, 2000). As the focus on entrepreneurship education and the cultivation of an entrepreneurial mindset through schooling continues to grow, entrepreneurship education has been steadily advancing (Kuratko, 2005). To gain better insights into the factors influencing entrepreneurial behavior, researchers have conducted studies across various industries and regions using survey analysis, experiments, and interviews (Fayolle et al., 2016; Mustafa et al., 2016; Al-Jubari et al., 2016).

5. PAPER RETRIEVAL

Turulja et al. (2020) conducted research on entrepreneurial ambitions and informal support, demonstrating that family and friends have a significant beneficial influence on entrepreneurial goals. However, it is important to critically assess the methodological limitations of their study, such as sample size and cultural context. Similarly, Wegner et al. (2019) utilized the theory of entrepreneurial promotion to show a strong correlation between entrepreneurial education and intent. Nevertheless, the study could benefit from a more in-depth exploration of how different types of educational interventions impact entrepreneurial outcomes. The studies by Lopes et al. (2020) and Rasool et al. (2021) emphasize the influence of environmental factors on entrepreneurial inclinations. However, it is crucial to

consider the socio-economic and infrastructural disparities between urban and rural areas that might contribute to these differences.

After reviewing research publications, it was found that there is an intrinsic relationship between neurology and entrepreneurship, which makes neuro-entrepreneurship a new and unexplored field of study. Research has looked at the practical implications of neuro-entrepreneurship in management and entrepreneurship, despite the challenges in expressing its theoretical and practical contributions (Cucino et al., 2021). This study provides a comprehensive guide for business owners and researchers interested in neuro-entrepreneurship research and emphasizes the importance of discussing the common approaches and trends in this field of study. The research uses bibliometric techniques, such as VOS viewer, to visualize the results of the literature analysis and understand research patterns in literature knowledge networks (Van Eck and Waltman, 2010).

The brain is essential to the human experience as it controls our thoughts, emotions, and actions, shaping our perception of the world (Seung, 2012). Despite its crucial role, our understanding of the brain's complex functions has historically been limited, especially in the field of entrepreneurship study (Alivisatos et al., 2013). Scholars interested in entrepreneurship are intrigued by the inner workings of the mind, but their comprehension of mental processes is hindered by insufficient tools. Rather than delving into the reasons and mechanisms behind entrepreneurial thinking, the focus is often on the traits and behaviors of entrepreneurs (Mitchell et al., 2002; Shane, 2000; Mitchell et al., 2005; Haynie et al., 2010).

The working definition of a nascent entrepreneur is an individual who is undertaking efforts to start a new venture alone or with the support of others. Entrepreneurial mindset refers to a creative cognitive ability to derive entrepreneurial behaviors and innovative applications. There has been a proliferation of educational courses and practical workshops that are focused on teaching the required skills and information for creating and executing new company ideas. This is a direct outcome of the notion of "Entrepreneurship" gaining major importance in the discourse of global business as well as the local context of the business.

Fayolle and Kuckertz (2013) argue that there is an ongoing debate about the content, objectives, and methods of entrepreneurship education, despite the increasing availability of such courses. Research shows contradictory outcomes regarding the impact of entrepreneurship education. Some studies suggest that there is no clear positive impact on the entrepreneurial intentions of undergraduate students (Graevenitz et al., 2010; Oosterbeek et al., 2010). According to Bennett (2006) and Mwasalwiba (2010), existing studies do not provide enough evidence to conclusively determine how current training methods affect the development of new entrepreneurs. There is also insufficient research to support active teaching methods, such as case studies, group discussions, and business simulations (Bennett, 2006; Mwasalwiba, 2010). Overall, there is a lack of consensus on the key factors influencing the entrepreneurial intentions of undergraduate students.

The plan for nascent entrepreneurship includes a recognized redesigned teaching technique based on existing research. According to Mwasalwiba (2010), traditional teaching approaches in higher education are limited by high costs, time-consuming nature, and divergence from ordinary university teaching practices. Osterwalder and Pigneur (2010) and Ries (2011) have presented innovative approaches to encourage the growth of prospective company owners, such as using a business model canvas combined with the lean start-up movement. Despite the potential of the Design Thinking (DT) method, there is currently a lack of evidence that it successfully fosters an entrepreneurial mindset among students (Daniel, 2016).

The focus of this research is to further review the ongoing discussion on the potential for entrepreneurship stemming from educational backgrounds. It aims to examine the contribution of factors such as entrepreneurial motivation, entrepreneurial self-efficacy, and personal difficulties on the formation of a nascent entrepreneurial mindset. As noted by Fayolle et al. (2006), the nascent entrepreneurial mindset is a critical factor in realistic entrepreneurial behavior,

representing the perspective and readiness for engaging in entrepreneurial activities. Within this realistic entrepreneurial behavior, the main influencing factor is the self-efficacy of potential entrepreneurs, which utilizes their intention and confidence levels (Fayolle et al., 2006). According to Daniel (2016), investigations of potential entrepreneurship are motivated by dynamic factors such as self-efficacy and exciting challenges against the crucial entrepreneurial mindset. Although Sri Lanka lags behind in implementing neuroscience into entrepreneurship, a few institutions, like the Institute of Growth Concept, have revolutionized Neuro-Energized Training (NET) techniques at the core of their methodology, resulting in an 80 percent impact on successful business startups (Institute of Growth Concept, 2016).

6. HETEREDOX PERSPECTIVE ON ENTREPRENEURSHIP

As noted by Smith et al. (2019), the intersection of entrepreneurship and region has become an increasingly important topic in the academic study of cultural aspects and communities worldwide. The authors conclude that social systems have a significant impact on entrepreneurship globally, influencing the beliefs, values, and traditions of people in various ways. Pidduck and Tucker (2022) found that mindful heterodoxy can emerge from the intersection of religious beliefs and business approaches within society's sub-systems, leading many entrepreneurs to exhibit behaviors and characteristics associated with heterodoxy. Given the complexity of the relationship between religion and business, further research in this area is necessary. Entrepreneurship also involves identifying future market trends and related products and services, requiring risk-taking. These risk-takers come from diverse religious backgrounds. Smith et al. (2021) highlight the need for examining the correlation between religion and entrepreneurial mindset, as well as the effects of religion on enterprises.

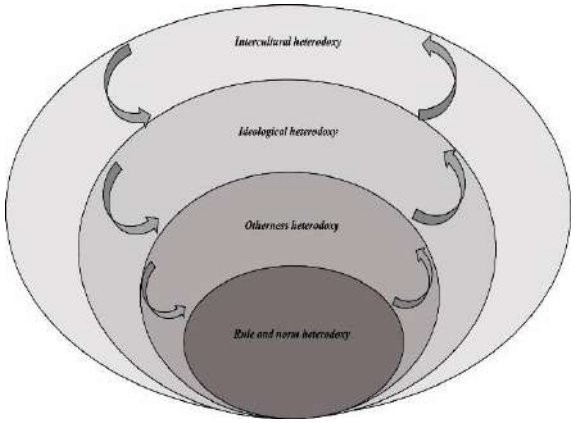

Figure 3: **The cascading contexts for meaningful heterodoxies.** (Source: Pidduck and Tucker, 2022)

Upon further analysis of the literature, it is evident that the R&E multiple compounding approach is based on the potential heterodoxy of entrepreneurship. Pidduck and Tucker (2022) highlighted two key aspects. The first aspect involves the movement of religious entrepreneurs' religious and cultural boundaries, which creates cultural barriers and conflicts for entrepreneurs, thus contributing to intercultural heterodoxy. The second aspect, defined as ideological heterodoxy, refers to discrepancies in deeply entrenched convictions and presumptions that may result in disputes. This aspect involves evaluating the deep assumptions and concepts of beliefs in the enterprise background in detail.

According to Smith et al. (2019), there are ideological conflicts that arise when assessing and pursuing economic opportunities due to the presence of different religious beliefs. These beliefs contradict established understandings of the relationship between religion and business. Another aspect is otherness heterodoxy. This involves considering opinions that deviate from expectations (Pidduck and Tucker, 2022). Otherness heterodoxy examines how faith-based thinking deals with skepticism and foreignness. Figure 3 illustrates the cascading contexts for meaningful heterodoxies, explaining their approach to managing social identity, legitimacy, inclusion/exclusion, and code of behavior. To effectively communicate with stakeholders, entrepreneurs need to use effective communication strategies (Fisher et al., 2017).

7. NEUROSCIENCE AND ITS ADVANCEMENT WITH ENTREPRENEURIAL COGNITION

The latest studies in neuroscience have shattered existing myths about the relationship between neuroscience and entrepreneurship, offering a new perspective on entrepreneurial behavior and cognition. Generally, entrepreneurs start by generating new ideas and then turning those ideas into profitable enterprises. However, this seemingly straightforward process involves a deep cognitive process. According to Shane, Locke, and Collins (2003), uncovering hidden advantages in new opportunities involves a cognitive transformation of an idea into a business. Thus, every new enterprise established today undergoes a profound cognitive process, beginning with a brainstorming session to create a product or service, identify the business's potential, and allocate its resources (Baron, 2007).

In discussions about entrepreneurship, the creativity of the entrepreneur is an important characteristic for generating ideas from various sources and turning them into profitable business ventures. This creativity is rooted in cognitive processes, as explained in cognitive science. According to Baron (2006), cognitive science involves studying pattern recognition and meaningful occurrences or changes. Baron and Ensley (2006) found that individuals with a strong cognitive framework are better at recognizing new patterns and business opportunities, and this ability is closely linked to the cognitive process. This understanding can improve the entrepreneurial mindset and dedication to pursuing new opportunities.

8. PRISMA FRAMEWORK

A significant way to identify potential entrepreneurs is by evaluating the business environment and establishing a venture. This approach is based on the well-structured framework defined by Mitchell et al. (2002) and is associated with entrepreneurial cognition. The study used the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) framework and VOS viewer to create network maps and a comprehensive framework for neuro-entrepreneurial education. It emphasized the use of neuroscientific techniques such as EEG and fMRI to study entrepreneurial cognition and behavior.

Articles were selected using the PRISMA framework and the Ryyan Systematic Review tool. Initially, 161 articles were found in the databases. After removing 60 articles due to duplication, ineligibility, and other reasons, 41 articles were considered eligible for screening. Out of these, 40 articles were excluded during screening and 20 articles could not be retrieved. This left us with 41 articles for further assessment. However, 26 reports were excluded as they were not primary research and were unavailable for analysis. Finally, a total of 15 articles met the inclusion criteria for critical review (see annexures 1, 2, and 3).

The Ryyan tool involves collaborators and a reviewer in deciding which articles to include or exclude based on specific criteria. The tool automatically filters out irrelevant articles and the final decision on which articles to include is exported from Ryyan.

9. CLUSTERS OF NEURO-ENTREPRENEURSHIP EDUCATION

The VOSviewer network maps demonstrate an attempt to visualize the components and their connections within neuro-entrepreneurship education. The analysis depicts two networks. Figure 4 displays the standard mapping, representing the two main elements of neuro-entrepreneurship education, "cognitive neuroscience" and "entrepreneurial introduces "neuro-entrepreneurship education" as the integration of the two main elements mapped separately in Figure 4 below.

The elements depicted in Figure 4 are not commonly emphasized in traditional entrepreneurial education. However, the networks illustrate the significant connections between neuroscience, decision-making processes, behavioral science, and technical tools such as Functional Magnetic Resonance Imaging (FMRI) in contemporary literature. This suggests the possibility of merging cognitive neuroscience and entrepreneurial education. Subsequently, we created a network map outlining the potential elements of 'neuro-entrepreneurship education'.

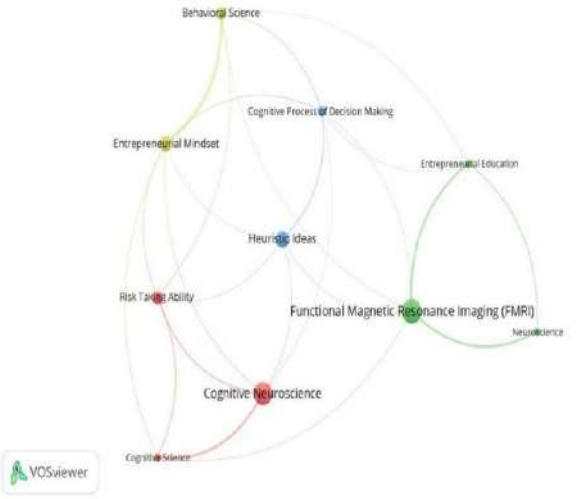

Figure 4: Mapping cognitive neuroscience and entrepreneurial education (Source: Authors' preparation using VOS viewer)

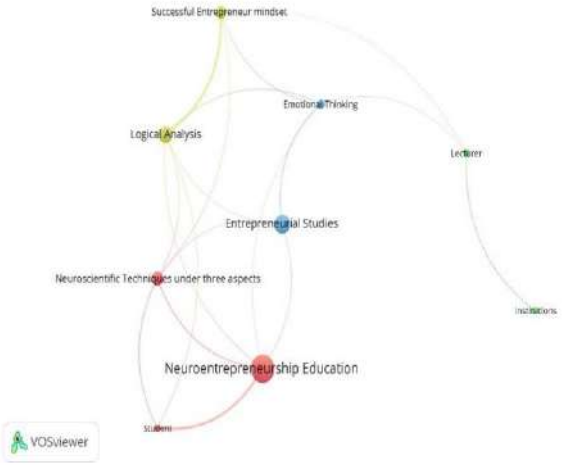

Figure 5: Mapping neuro-entrepreneurship education (Source: Authors' preparation using VOS viewer)

The map emphasizes the importance of a student-centered approach, which is vital for developing an entrepreneurial mindset by integrating key neuroscientific techniques with entrepreneurial education. These network maps are valuable for gaining insights into creating a framework for neuro-entrepreneurship education and its development. Additionally, incorporating interdisciplinary aspects into entrepreneurial education, and establishing strong connections between institutions and students, as well as emotions and logical analysis, are crucial for developing a more practical and adaptable model and framework for entrepreneurial education today.

The education system plays a crucial role in shaping prospective entrepreneurs. However, in the Sri Lankan context, there are limitations to its impact on neuro-entrepreneurship. Factors such as early childhood experiences, particularly trauma, genetically endowed personality traits, and environmental influences significantly influence career choice. These factors can overshadow the effects of educational interventions, meaning not all educational efforts will necessarily result in the production of entrepreneurs. Addressing these influences requires a holistic approach beyond the education system to foster an entrepreneurial mindset effectively. Therefore, while the purpose of education is to create the potential for entrepreneurship, it cannot guarantee that all individuals will become entrepreneurs.

10. CONCLUSSION

The study's results highlight the potential of integrating neuroscience into entrepreneurship education, particularly in developing Asian nations. The findings emphasize the importance of interdisciplinary collaboration by revealing a strong relationship between brain activity, entrepreneurial behavior, and mindset. To better understand specific features of entrepreneurial behaviors, the study recommends incorporating behavioral applications such as transcranial magnetic stimulation. It elucidates the cognitive factors influencing decision-making and underscores the importance of neuroplasticity.

The study not only provides a deep understanding of cerebral hemispheres and encourages multidisciplinary insights for a comprehensive understanding of entrepreneurship, but also advocates for a shift towards a neuroscientific perspective. It emphasizes the importance of integrating neuroscientific techniques into education for those aspiring to become entrepreneurs. A more advanced understanding of entrepreneurship is made possible by gaining insights into decision-making processes, risk-taking behavior, and the entrepreneurial mindset.

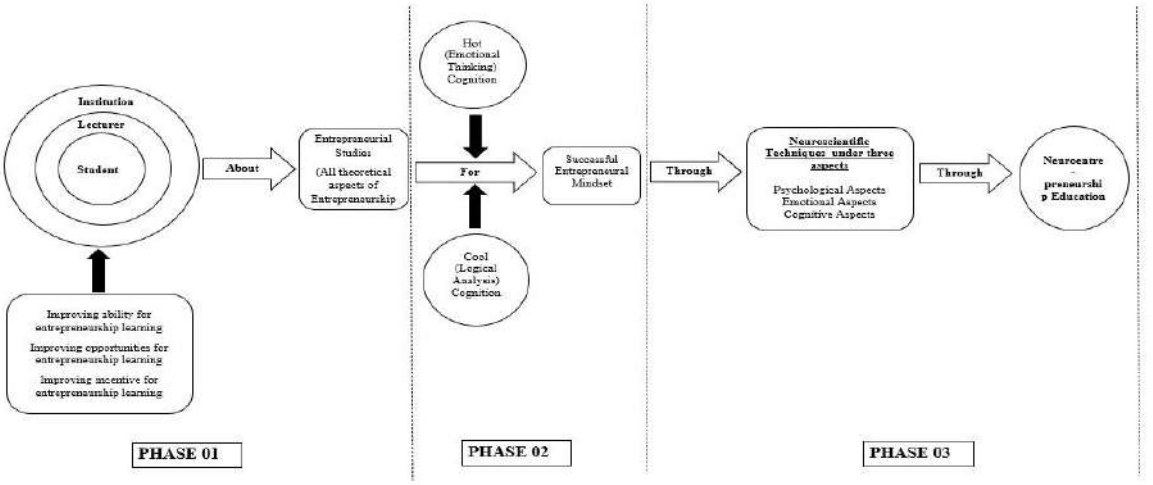

Figure 6: Proposed Entrepreneurial education framework for Neuro-entrepreneurship
(Source: Authors' preparation)

The study emphasizes the importance of understanding the brain's role as a micro-antecedent of human behavior and decision-making for aspiring business owners to successfully navigate the challenges of the entrepreneurial journey. It also highlights the increasing significance of neuroscientific tools such as ERP, fMRI, EEG, and eye tracking in the study of entrepreneurship. The study underscores the value of experimental methods in improving entrepreneurial theory and establishing causal relationship.

The conclusion emphasizes the importance of further research into the intricacies of entrepreneurial cognition. It recognizes that as neuroscience-related studies increase, prospective business owners have more opportunities to enhance their understanding of entrepreneurial thinking. This research suggests that neuro-entrepreneurship can be a viable strategy for cultivating a comprehensive entrepreneurial mindset in Asian nations. It calls for a shift in the field of entrepreneurship education.

The practical applications and investigations can help make neuro-entrepreneurship a viable strategy through various methods such as research, experimental games (e.g., BART game, dictator game, and real effort task), pilot programs in educational institutions, neurofeedback and cognitive training, mindfulness and stress management workshops, cross-disciplinary collaborations with neuroscientists, psychologists, and entrepreneurial ecosystem management.

In Figure 6, the pedagogy of entrepreneurial education within the university system consists of three levels: the institution at the first level, lecturers at the second level, and finally a student-centered phase. All these levels are influenced by improving the ability for entrepreneurship learning, improving opportunities for entrepreneurship learning, and improving incentives for entrepreneurship learning. These improving dimensions tend to explain the "about" approach, which emphasizes theoretical education and the traditional way of teaching entrepreneurship. This phase represents the traditional way of entrepreneurial education that has taken place in Asian countries.

The study by Ghina et al. (2017) departs from the traditional "about" and "for" approaches and instead adopts a "through" approach. They develop a new framework based on the theoretical model, incorporating key dimensions and neuroscientific techniques. In the second phase, the focus shifts to the "for" approach, emphasizing the practical application of entrepreneurial theories in real-world contexts to support a successful entrepreneurial mindset.

The study also discusses "hot cognition," which refers to decision-making and cognitive processes influenced by emotions, in contrast to "cool cognition," which is more analytical and less influenced by emotions. Despite the limited availability of these techniques in local contexts, the third phase of the study emphasizes the application of

neuroscientific techniques in three aspects: psychological, emotional, and cognitive.

The psychological aspects refer to the mental processes and behaviors that contribute to an individual's thoughts, feelings, and actions. Techniques such as FMRI, EEG, and MEG are applied to study emerging entrepreneurial education. Emotional aspects involve subjective experiences, expressions, and the regulation of emotions, using FMRI, Positron Emission Tomography (PET), and Heart Rate Variability (HRV) monitoring in the field of neuro-entrepreneurship. Cognitive aspects involve mental processes such as perception, attention, memory, language, problem-solving, and decision making. These aspects capitalize on the use of FMRI, Event-Related Potentials (ERPs), and TMS. This approach emphasizes a pedagogy of education revolutionized with the experimental application of neuro entrepreneurship education, focusing on the idea of "through" rather than "for" or "about".

The study's key findings show the significant impact of incorporating neuroscientific techniques into entrepreneurship education, especially in developing Asian countries. This integration combines cognitive neuroscience with entrepreneurial mindsets and behaviors. While the study emphasizes the importance of interdisciplinary collaboration, it also recognizes limitations such as the influence of early childhood experiences and genetic traits on entrepreneurial outcomes. Despite these challenges, the research offers valuable insights into the neural basis of decision-making and risk-taking in entrepreneurship, contributing to a broader scientific understanding of entrepreneurial cognition. The implementation of this framework is feasible when applying neuroscientific techniques using behavioral experimental models and applications. Future research can further explore these interdisciplinary approaches and address the practical implications for educational frameworks and policy development in fostering a comprehensive entrepreneurial mindset.

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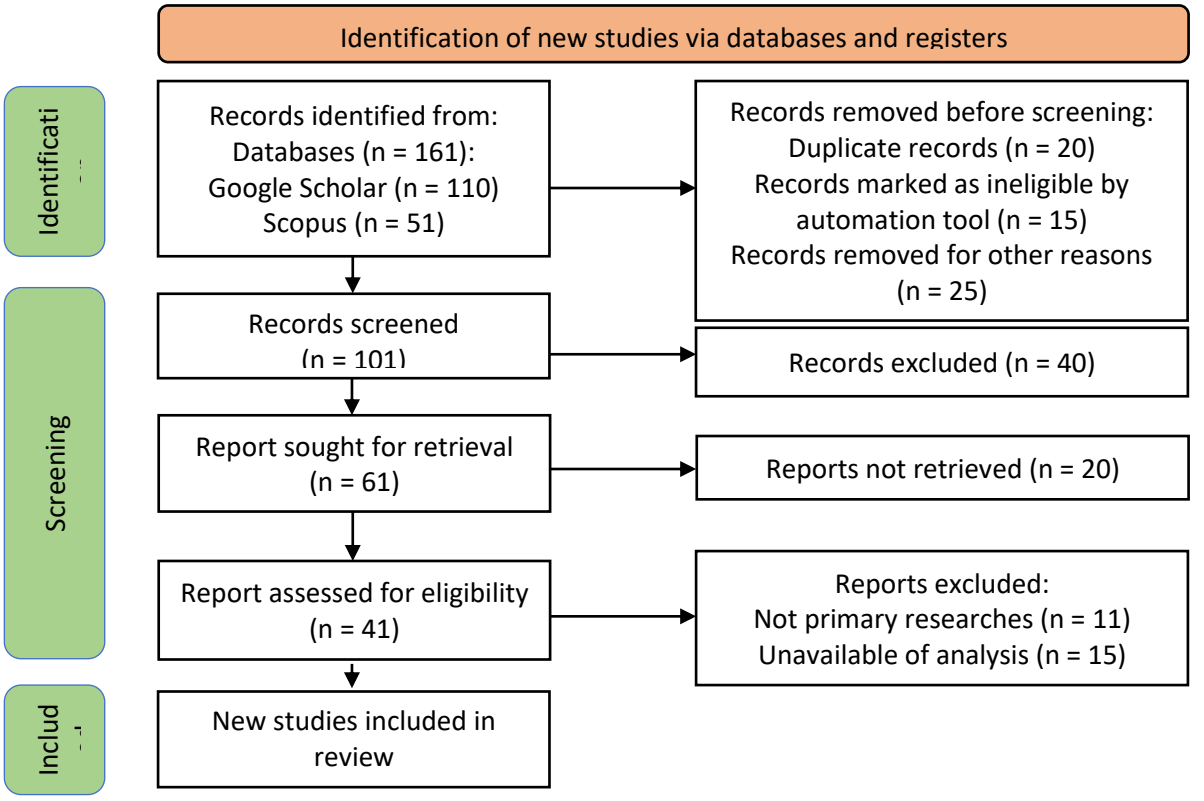
12. ANNEXURES

Annexure 1: PRISMA (Preferred Reporting Items for Systematic Reviews) framework



Annexure 2: Sample of Ryyan tool

Annexure 3: PRISMA-stages

Stage	Number of Articles Identified	Number of Articles Screened	Number of Articles Eligible	Number of Articles Included
Initial Database Search	161	141	126	101
Duplicates Removed	20			
Removed for other Reason	25			
Titles and Abstracts Screened		101	61	41
Articles Excluded (with reasons)			Not primary researches: 11, unavailable of analysis: 15,	
Articles included in review			15	15

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THE EFFECT OF Z-SCORE ON YEAR GRADE POINT AVERAGE (YGPA) AND FINAL GRADE POINT AVERAGE (FGPA) IN FACULTY OF ENGINEERING, GENERAL SIR JOHN KOTELAWALA DEFENCE UNIVERSITY (KDU)

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ABSTRACT

A collection of 182 Intake 35 day scholar undergraduates who had followed the Local GCE Advanced Level examination from the Faculty of Engineering, General Sir John Kotelawala Defence University (KDU), was selected. Data was collected from the several departments and units of KDU. The Grade Point Average (GPA) was considered the scale of a student's academic performance in the study. A descriptive analysis was performed to differentiate the configuration of the data and the relationship between the Year Grade Point Average (YGPA), and Final Grade Point Average (FGPA) variables with the Z-Score. Spearman and Kendall rank correlation tests were performed in the analysis. The results indicated that the Z-score has a comparatively strong positive relationship with student's performance at the university in their first year and the class selection.

KEYWORDS: *FGPA, Student's performance, YGPA, Z-Score*

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1. INTRODUCTION

Higher education grants a society robust financial capability by producing a powerful labor force. University graduates have significant roles in government and private-sector employment in Sri Lanka. Thus, the student's educational performance is a more acceptable indication of the country's prospective development.

The academic performance of undergraduates may depend on various factors, including the institution's facilities, the students' backgrounds, their prior academic success, their mental and physical wellness, and the institution's social influence. It might change for various reasons during various student life phases. Previous research (McKenzie & Schweitzer, 2001) indicates that previous school achievement significantly predicts university student performance.

After high school, a student's performance in Sri Lanka is assessed based on their grade point average (GPA) during their university education. As a result, this study concentrated on the effect of students' GCE Advanced Level Z-score on year-wise and final GPAs.

This study aimed to determine the effect of standardized secondary educational achievement on GPA in the Faculty of Engineering, General Sir John Kotelawala Defence University (KDU). Since the students' academic performance changes periodically, administrative bodies must identify the effects of previous educational performance on an undergraduate's GPA. Accordingly, the investigation aims to determine whether there is an effect on students' secondary education performances (GCE A/L) on the Grade Point Average value throughout their university years.There are eleven faculties in the General Sir John Kotelawala Defence University (KDU): Faculty of Engineering, Faculty of Medicine, Faculty of Computing, Faculty of Management, Social Sciences and Humanities, Faculty of Defence and Strategic Studies, Faculty of Law, Faculty of Allied Health Science, Faculty of Built Environment and Spatial Sciences, Faculty of Technology, Faculty of Criminal Justice, and Faculty of Graduate studies.

The Faculty of Engineering has the highest student population at General Sir John Kotelawala Defence University. The faculty's six departments of study, i.e., Department of Aeronautical Engineering, Marine Engineering, Mechanical Engineering, Civil Engineering, Electrical Electronic & Telecommunication Engineering, and Mathematics, offer B.Sc. in Engineering (Hons) degree programs in nine disciplines.

The students are selected for the university based on the results of their secondary education, GCE Advanced Level examination Local, Cambridge, and Edexcel. The undergraduates follow a set of standard modules in their first semester. They are selected for the respective discipline at the beginning of the second semester based on their preference. Academic performance is evaluated using the Grade Point Average (GPA) value. GPA is computed for each semester (SGPA), for each year (YGPA) separately, and calculated for the entire degree program (FGPA). The classes are determined according to the Final Grade Point Average (FGPA) value.

Calculation of Grade Point Average value

The GPA value is computed by dividing the total credits weighted on grade point values by the total number of credits. Their GPA determines the student's academic performance based on the final grades, computed using semester-end examination marks and continuous assessment grades. The university calculates the GPA based on the grades obtained by students and relevant point values, as shown in Table 1.

The GPA is calculated by dividing the total credit-weighted score by the total number of credits as follows.

$$GPA = \frac{\sum X_i Y_i}{\sum Y_i}$$

where,

Xi= Grade point value of the i^{th} course unit

Y_i = Number of credits in the i^{th} course unit

Table 1: Grade and relevant point values for students' final marks

Range of Marks	Grade	Point Value
100-85	A+	4.2
84-75	A	4.0
74-70	A-	3.7
69-65	B+	3.3
64-60	B	3.0
59-55	B-	2.7
54-50	C+	2.3
49-45	C	2.0
44-40	C-	1.7
39-35	D+	1.3
ES<35	IE	0.0
CAS<35	IA	0.0
ES<35 & CAS<35	IB	0.0

Background

Most educational academies consider the productivity of graduates that they will contribute to the community. Since university students' productivity is reliant on their academic success, most researchers have considered students' grade point average (GPA) as an ascertaining feature for their research investigations (McKenzie & Schweitzer, 2001; Erdem et al., 2007; Mushtaq & Khan, 2012). Even though the number of graduates in the labor market is increasing, finding appropriate employment with mere knowledge is difficult. Employers prefer professionals with a higher cumulative GPA (Erdem et al., 2007). Ali et al. (2009) state that a country's social and economic growth affects students' academic performance.

Evidently, a country's well-educated human resources ensure a more promising future. McKenzie and Schweitzer (2001) discovered that prior academic performance impacted pupils' undergraduate academic success. The study examined the academic, psychological, cognitive, and demographic factors of first-year university students' academic performance. The study's conclusions are based on 197 students from a large metropolitan computer-based university's Science and Information Technology faculties. To determine the significant effect of the aspects, a descriptive analysis, standard regression models, and analysis of variance tables (ANOVA) were used. Erdem et al. (2007) used cumulative grade point averages to indicate student performance at Turkey's Gasiosmanpasa University. This research was conducted to identify the socio-economic and demographic characteristics that affect academic achievement. Even though previous academic performance and the nationwide university admission test (OSS) scores were evaluated in the study, they were irrelevant to the analysis. Martha (2009) investigated the determinants influencing undergraduate academic achievement at Uganda Cristian University for her Master of Arts dissertation. This study examined factors connected to academic performance in 340 undergraduates at Uganda Christian University. Admission points for advanced level and diploma programs, parents' socioeconomic status, and previous school experience have all been found to influence academic achievement. Chathuranga, C.D. (2016) investigated the effect of Past Education Performance on Grade Point averages in the Faculty of Social Sciences, University of Kelaniya, Sri Lanka, using a sample of 274 undergraduates. This study has determined that, except for the Grade 5 scholarship examination results, both the results of the GCE O/L and GCE A/L have a positive association with student's performance at the university.

Abdelfattah et al. investigated how entrance scores relate to short-term and long-term success in Engineering Education. They found that high school coursework, general ability, and achievement tests significantly correlated with preparatory year GPA, while first to third-year GPAs were predictive of cumulative GPAs at graduation. Lawal et al. similarly examined the predictive validity of first-year GPA on final-year degree classification for management and social science students in a Nigerian University. They discovered a significant, albeit negative, correlation between first-year GPA and final-year CGPA among management science graduates. Kennedy and Ebuwa explored how University entry scores (UTME) and Post Unified Tertiary Matriculation Examination (PUTME) predict undergraduate final-year CGPA in Nigeria. Despite analyzing data from 436 undergraduate

students across four departments, they found that combined UTME and PUTME scores did not significantly predict final-year CGPA. Oguntunde et al. investigated the relationship between first-year results and final graduating grades in a Nigerian University. They developed a model that accurately predicts final year CGPA based on first-year results through correlation and regression analysis, indicating a robust linear relationship between GPAs and academic progression.

Nurudeen et al. delved into the practical implications of the predictive power of first-year GPA on final-year CGPA and the influence of demographic attributes on academic achievement. Their findings, which emphasized the strong positive relationship between first-year GPA and final-year CGPA and the lack of significant correlation between demographic characteristics and final-year CGPA, provide valuable insights for educators and policymakers in enhancing academic success.

Several diverse studies, including those by Abdelfattah et al., Abdulkadir and Ogwueleka, Lawal et al., Debaliz et al., and Oguntunde et al., have all concluded that there is a robust linear relationship between Grade Point Average and Cumulative Grade Point Average, influencing students' academic achievement. This wide range of research demonstrates the comprehensive exploration of this topic.

2. METHODOLOGY

Selection of Subjects

The students from intake 35 who graduated in 2022 were selected for this study. The number of students in the faculty was obtained from the Dean's office of the Faculty of Engineering, KDU. According to that data, 201 engineering day scholars were in intake 35, while the total number of engineering students (Officer Cadets and Day scholars) in intake 35 was 246. Since the Z-score is not calculated for the GCE Advanced Level offered by Cambridge and Edexcel, 182 day scholars who completed the Local GCE Advanced level examination were selected for the study, as shown in Table 2.

Table 2: Number of engineering undergraduates in intake 35

Discipline	Number of Students (Officer Cadets + Day scholars)	No. of day scholars	No. of day scholars selected for the study
Aeronautical Engineering (AE)	15	7	7
Aircraft Maintenance Engineering (AME)	7	5	5
Biomedical Engineering (BM)	14	10	6
Civil Engineering (CE)	55	51	47
Electrical and Electronic Engineering (EE)	53	44	42
Electronic and Telecommunication Engineering (ET)	31	29	28
Marine Engineering (MR)	10	-	-
Mechanical Engineering (ME)	28	24	24
Mechatronics Engineering (MC)	33	31	23

Collection of Data

The list of Engineering undergraduates of intake 35 with their secondary education performance (Z-score) was obtained from the Enlistment Department of KDU. Undergraduate student performance data, such as year-wise grade point average and final GPA values, was collected from the Examination Department, KDU.

The dataset was developed by integrating the components collected from the respective departments. The data set consisted of six continuous variables; Z-score, 1st year YGPA, 2nd year YGPA, 3rd year YGPA, 4th year YGPA and FGPA of students and four string type variables; Discipline, Registration number, Name, and Class.

Analysis of Data

The dataset was uploaded into the R studio for analysis.

Histograms and box charts were plotted for the six continuous variables. Once the outliers were identified, data was cleaned for the six continuous variables by withdrawing them. Then the analysis was executed on the cleaned dataset.

Since the Z-Score was considered the response variable, the normality was checked for the remaining variables, GPAs. The histogram, density plot, and quantile-quantile plot were plotted for the GPAs. Then the skewness and kurtosis were calculated to check the normality of the continuous variables.

The tests of Shapiro-Wilk and Kolmogorov-Smirnov were used to conduct a normality test.

The following hypotheses were tested in normality tests.

H_0: The data come from a normally distributed population.

Versus

H_1: The data come from a population that is not normally distributed.

If the test is significant, reject the normality assumption for the distribution.

Since the normality assumption was not satisfied, nonparametric tests were used to analyze the data. A suitable nonparametric test called the distribution-free test, i.e., Spearman rank correlation test, and Kendall's tau-c Rank correlation, have been considered for the study.

The tests of Spearman Rank Correlation test and Kendall Rank Correlation were used to test for the associations between Z-score and GPAs.

The following hypotheses were tested.

H_o: There is no association between two continuous variables.

Versus

H_1: There is an association between two continuous variables.

If the test is significant, reject the null hypothesis.

3. RESULTS AND DISCUSSION

Preliminary Analysis

A preliminary analysis was conducted to identify the outliers. Histograms and box plots were plotted for the six continuous variables.

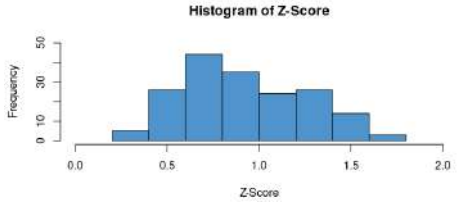

Figure 1: Histogram of Z-Score

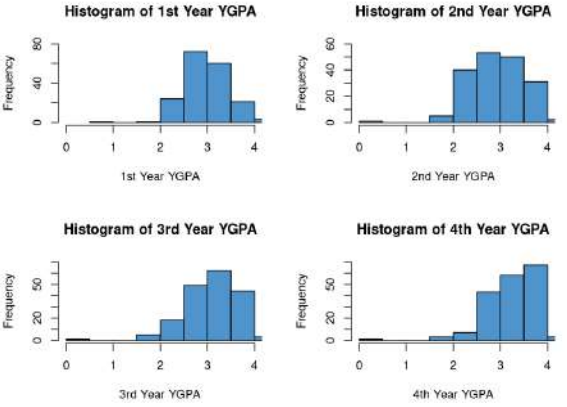

Figure 2: Histograms of 1st, 2nd, 3rd and 4th Year YGPA

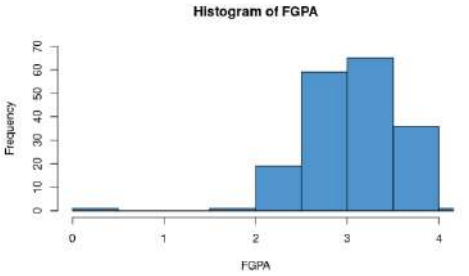

Figure 3: Histogram of FGPA

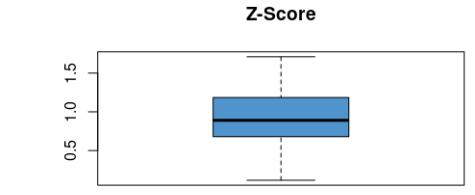

Figure 4: Box plot of Z-Score

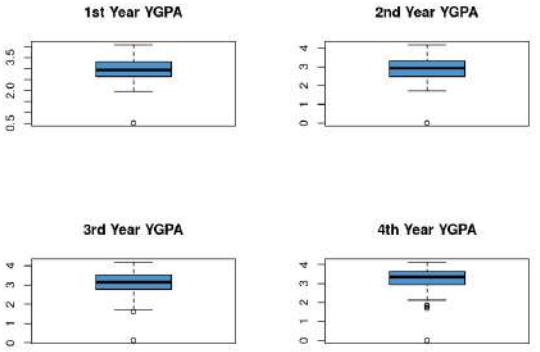

Figure 5: Box plots of 1st, 2nd, 3rd and 4th Year YGPA

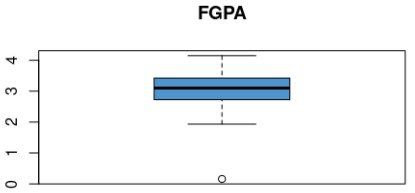

Figure 6: Box plot of FGPA

Data Cleaning

The number of outliers in each variable is represented in Table 3.

Table 3: Outliers

Variable	Number of Outliers
Z-score	-
1st year YGPA	1
2nd year YGPA	1
3rd year YGPA	2
4th year YGPA	4
FGPA	1

All five outliers were identified and removed to obtain the cleaned dataset. This cleaned data set consists of the data of 177 students.

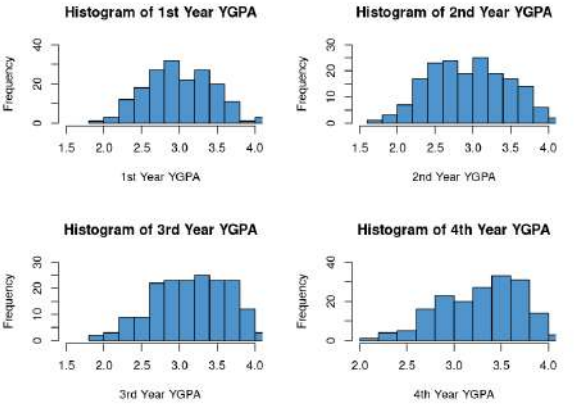

Figure 7: Histograms of cleaned 1st, 2nd, 3rd and 4th year YGPA

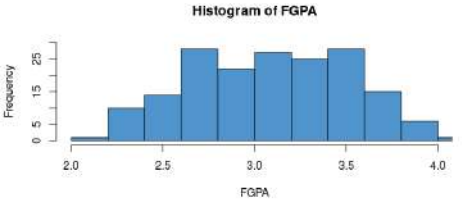

Figure 8: Histogram of cleaned FGPA

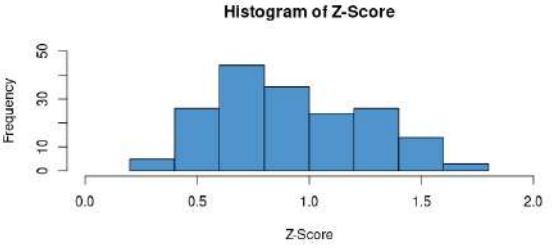

Figure 9: Histogram of cleaned Z-score

Test of assumption of normality of GPA

The density plot of the 1st year YGPA data shows that the distribution was not symmetric and right skewed. Both histogram and density plot illustrate that the shape of both plots deviates from the bell-shaped behavior of a normal distribution. Therefore, the 1st year YGPA data are not normal.

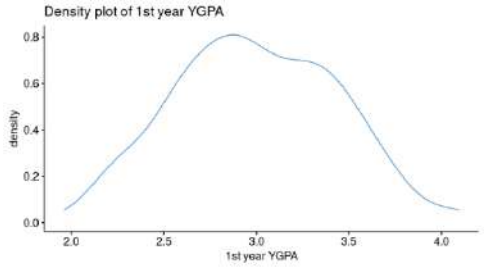

Figure 10: Density Plot of 1st year YGPA

The density plot of the 2nd year YGPA data shows that the distribution was not symmetric. Thus, the 2nd year YGPA data are not normal.

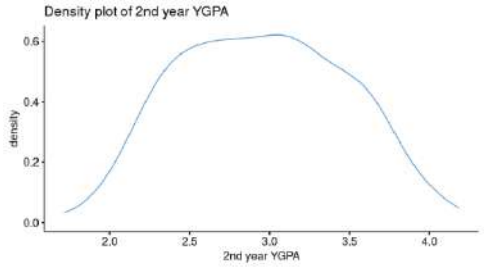

Figure 11: Density Plot of 2nd year YGPA

The density plot of the 3rd year YGPA data shows that the distribution was not symmetric and left-skewed. Therefore, the 3rd year YGPA data are not normal.

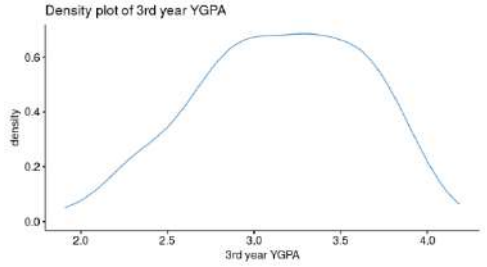

Figure 12: Density Plot of 3rd year YGPA

The density plot of the 4th year YGPA data shows that the distribution was not symmetric and left-skewed. Therefore, the 4th year YGPA data are not normal.

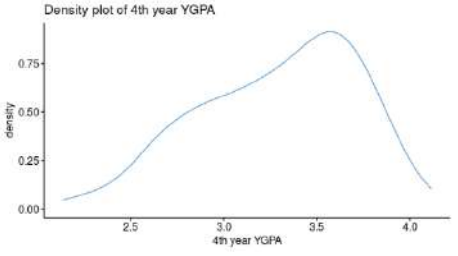

Figure 13: Density Plot of 4th year YGPA

The density plot of the FGPA data shows that the distribution was not symmetric and left-skewed. Therefore, the FGPA data are not normal.

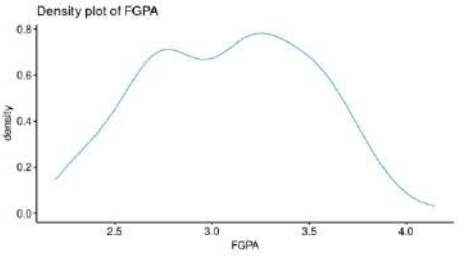

Figure 14: Density Plot of FGPA

The normal quantile-quantile plot illustrates that the more points vary significantly from a 45° reference line, the less likely a normal distribution is. Hence, the 1st year, 2nd year, 3rd year and 4th year YGPAs and FGPA data are not normal according to the Q-Q plot.

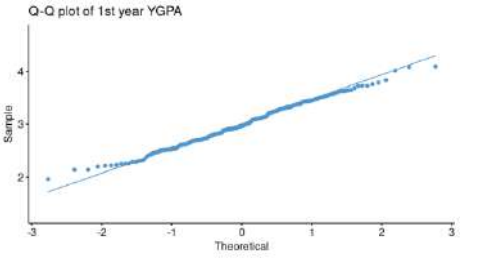

Figure 15: Normal Q-Q plot of 1st year YGPA

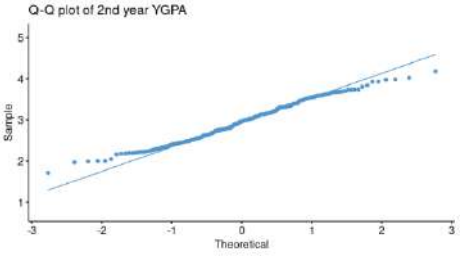

Figure 16: Normal Q-Q plot of 2nd year YGPA

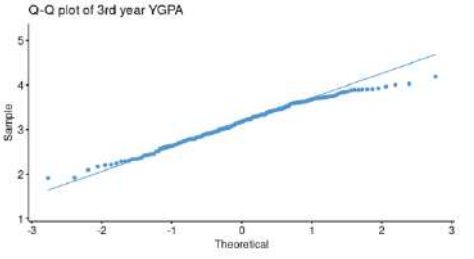

Figure 17: Normal Q-Q plot of 3rd year YGPA

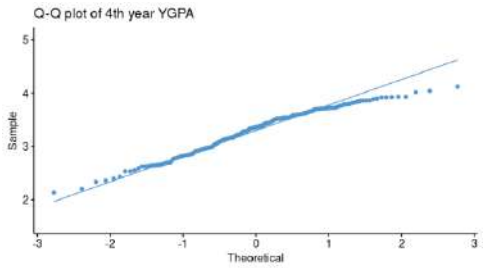

Figure 18: Normal Q-Q plot of 4th year YGPA

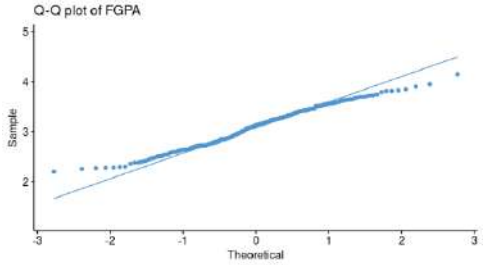

Figure 19: Normal Q-Q plot of FGPA

The skewness and Kurtosis were calculated for five variables to check the normality. R studio output is given in Table 4.

Table 4: Skewness and Kurtosis of GPA variables

Variable	Skewness	Kurtosis
1st year YGPA	0.0678	2.4700
2nd year YGPA	0.0644	2.199
3rd year YGPA	-0.2632	2.3957
4th year YGPA	-0.4374	2.4236
FGPA	-0.0414	2.1718

The skewness of the 1st year YGPA and 2nd year YGPA were positive; the tail was on the right side of the distribution. Further, the skewness of the 3rd year YGPA, 4th year YGPA, and FGPA were negative; the tail was on the left side of the distribution. Kurtosis of all variables is less than three, and it was a playkurtic, suggesting it produces fewer and less extreme outliers than the normal distribution. Since skewness is positive and Kurtosis is less than three. Thus, according to the skewness and Kurtosis, the 1st year YGPA and 2nd year YGPA data are not normal. Further, since skewness is negative, and Kurtosis is less than three. Thus, according to the skewness and Kurtosis, the 3rd year YGPA, 4th year YGPA, and FGPA data are not normal. R studio outputs of the test of Shapiro-Wilk and Kolmogorov-Smirnov were summarized in Table 5.

According to the Shapiro-Wilk normality test, students' distributions of first- and second-year YGPAs are normal. The distribution of 3rd year YGPA, 4th year YGPA, and FGPA is not normal. However, according to the Kolmogorov-Smirnov test, all the GPA variables are not normal. In consideration of this, the categorized students' GPA was selected as the response variable for the subsequent data analysis of univariate and advanced analysis. Nonparametric tests were performed to analyze the data since the population did not have a specific distribution, such as a normal distribution.

As the study concentrated on university students' academic performance, the student's class division was selected as the dependent variable for further investigations.

Class Distribution

The classes have been calculated using the students' FGPA values. The distribution of the categorized GPA values under standard criteria; First class (GPA > 3.7), Second class (Upper Division) (3.3<GPA>3.7), Second class (Lower Division) (3.0<GPA<3.3), General pass (2.0<GPA<3.0) and Not Completed (GPA<2.0) are represented in the Figure 20.

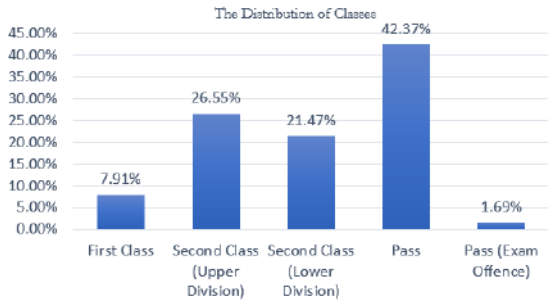

Figure 20: Class Distribution

The figure shows that 7.91% of students achieved first-class. The most significant number of students received general passes based on their grade point averages. 34.46% of students (61 out of 177) received first or second upper classes (equal to or more than 3.3 grade

point value). The percentage of students who had a class was 55.93%.

Test for the Normality of Z-Score

It is essential to identify whether the distribution of the Z-score is normally distributed. R studio outputs of the test of Shapiro-Wilk and Kolmogorov-Smirnov were summarized in Table 6.

The Z-score rejected the null hypothesis that the data came from a normally distributed population, according to Kolmogorov-Smirnov and Shapiro-Wilk statistical tests.

Relationship between GPAs and Z-score

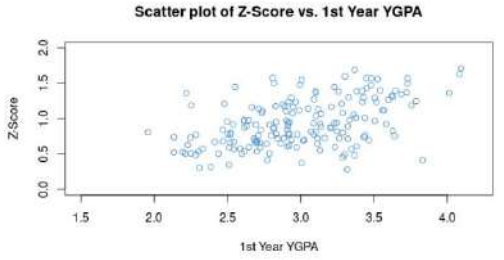

Figure 21: Scatter plot of Z-score vs 1st year YGPA

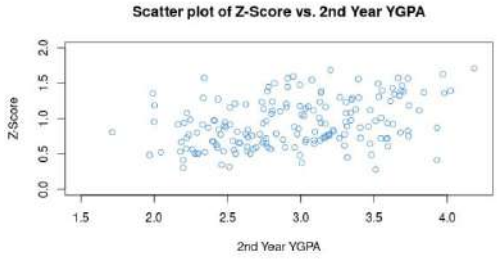

Figure 22: Scatter plot of Z-score vs 2nd year YGPA

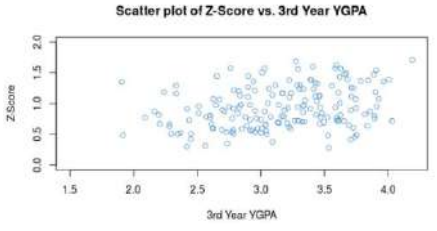

Figure 23: Scatter plot of Z-score vs 3rd year YGPA

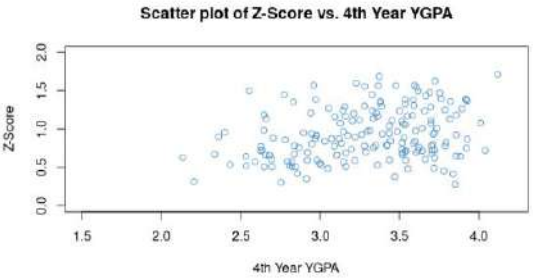

Figure 24: Scatter plot of Z-score vs 4th year YGPA

Based on the scatter diagrams, there was a positive relationship between GPA variables and the Z-score.

Statistical Test Results

R studio outputs of the test of Spearman Rank Correlation and Kendall Rank Correlation were summarized in Table 7.

According to Table 7, it was obvious that each pair of variables is positively significant at the 5% level of significance for both tests. Therefore, the null hypothesis is rejected, and it concluded that there is an association between each pair of variables.

The Spearman and Kendall Rank Correlation coefficients were positive values for each pair of variables. There is a strong positive correlation between Z-score and the 1st year GPA than the 2nd, 3rd, and 4th year GPAs in both tests. It is observable that the correlation between the Z-score and YGPA decreases drastically through the second and third years of students' undergraduate period. Then it decreases slightly in the 4th year.

Table 5: Tests of Normality

	Shapiro-Wilk		Kolmogorov-Smirnov	
	Test Statistic	Significant Value	Test Statistic	Significant Value
1st year YGPA	0.99156	0.3885	0.97798	2.2e-16
2nd year YGPA	0.98494	0.05387	0.96984	2.2e-16
3rd year YGPA	0.98411	0.04177	0.97183	2.2e-16
4th year YGPA	0.97039	0.0008046	0.98355	2.2e-16
FGPA	0.98295	0.02925	0.98589	2.2e-16

Table 6: Test for normality of Z-score

Shapiro-Wilk		Kolmogorov-Smirnov	
Test Statistic	Significant Value	Test Statistic	Significant Value
0.97081	0.0008981	0.63915	2.2e-16

Table 7: Tests for Association

	Spearman's Rank Correlation Test		Kendall Rank Correlation Test	
	Significant Value	Correlation Coefficient	Significant Value	Correlation Coefficient
Z-Score vs 1st year YGPA	3.143e-11	0.4724838	4.016e-11	0.3343934
Z-Score vs 2nd year YGPA	8.933e-07	0.3594692	6.415e-07	0.2520069
Z-Score vs 3rd year YGPA	0.0001276	0.2840148	0.0001173	0.1949904
Z-Score vs 4th year YGPA	0.0003914	0.2636555	0.00038	0.1799146
Z-Score vs FGPA	1.593e-07	0.3816638	8.199e-08	0.2714924

Further, a strong positive correlation exists between the Z-score and the Final GPA value. However, it could not be more potent as the correlation between 1st year GPA and Z-score.

This study aimed to identify whether students' performance in the GCE Advanced Level impacted their GPA. However, the Z-score was not normally distributed according to the descriptive test results in the study.

According to the study results, a positive relationship existed between Z-score and the student's GPAs. The fact that there is a positive association between the

A/L examination performance and the student's first-year YGPA is a noteworthy finding in the study since the A/L examination is the last performance indicator at the school level before university admittance.

Moreover, there is a drastic decrease in the correlation between the Z-score and the year GPA values throughout the undergraduate period. Students' interest in studying is decreasing during their undergraduate years.

For further study, it is essential to conduct a future study to identify the factors that affect the lower academic performance of students at the university, even if they had satisfactory performances in school.

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THE CONCEPT OF 'INVENTIVENESS OF MACHINES': HOW READY IS PATENT LAW TO AFFORD THE CREATIVE INVENTIVENESS OF ARTIFICIAL INTELLIGENCE?

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ABSTRACT

Making science fiction a reality, Artificial Intelligence (AI) has become a transformative drive in almost every aspect of human life today. With the advancements of modern technology, AI has acquired the ability to think like humans and create inventions that are economically worthwhile. The concept of 'inventiveness of machines' has become a focal point in the field of intellectual property law at present. It has compelled the world to reconsider the parameters of patent law in terms of protecting AI inventors and inventions of AI. Simultaneously, the procurement of patents for inventions of AI has posed challenges not only in the legal field but also in ethical and moral aspects. As AI is gradually becoming an undeniable part of human life, every nation will have to adopt the developments of AI technology into their legal systems sooner or later. Taking the prevailing definitions of 'inventor' into account, this research mainly discusses whether machine inventors and human inventors be given equal protection of law or whether there should be different dimensions of protection. This paper also discusses the moral and ethical dilemma of granting legal recognition for AI inventors while examining the capability of existing legal framework including Sri Lanka in accommodating the inventiveness of machines. This research was carried out using mixed method approach. Literature review, qualitative and empirical research methodologies and comparative analysis were incorporated to strengthen the study. The paper concludes by highlighting the need of legislative intervention of competent authorities to reconsider the legal parameters to accommodate the possible challenges waiting to be imposed by inventiveness of machine in future. This paper also introduces the concept of 'collaborative inventiveness of humans and AI' and suggests recommendations to amend existing laws in a manner that they afford the technological advancements of modern times.

KEYWORDS: *Artificial Intelligence, Patent Law, Inventiveness, Machines*

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1. INTRODUCTION

"Invention by Artificial Intelligence is the future of innovation"
(Schuster, 2018, p.1945)

Having hypothesized and theorized in the 1950's, Artificial Intelligence has become a practical prospect of daily human life today. It has revolutionized the traditional methods in industries, modes of communication, problem solving, businesses, the way things work and even the ways of thinking. As advancements in AI technologies continue to evolve, there emerge critical legal and ethical questions, especially within the realm of intellectual property law, including patent law. Despite the considerable interest mounting up on artificial intelligence and the challenges it presents to human society, there has been a notable lack of scholarly consideration given towards how AI impedes the smooth function of patent law. According to Ebrahim (2020), academics have given very little or insufficient attention to the obstacles AI imposes on the continual function of patent law both theoretically and policy-wise. In an era, in which the world is greatly driven by AI, the need for more academic research on patent law and AI is indispensable in-order-to clarify and pilot across the complexities arising due to rapid technological advancements. This paper attempts to initiate a timely conversation on the concept of 'inventiveness of machines' focusing on the preparedness of patent law to afford the inventive prowess of AI, internationally and locally.

The major objectives of this research are; 1.To investigate the present status of patent law in relation to AI and the necessity of reconsidering the 'inventor' in the context of AI technology. 2. To analyze the legal, moral and ethical repercussions in recognizing AI inventorship. 3. To assess the effectiveness of prevailing laws in protecting inventions created by AI and 4 To propose statutory recommendations to accommodate the creativeness of machines into current legal frameworks. Hence, this research will be guided by four research questions; 1. How should the conventional definition of 'inventor' be reconsidered to assimilate inventiveness of machines within the prevailing IP law framework? 2. What are the legal, moral and ethical repercussions of recognizing AI inventorship? 3. How effective are the existing domestic and international legal frameworks in protecting inventions created by AI? 4. What statutory interventions are necessary to address the contemporary and future challenges posed by inventiveness of machines?

The theoretical framework of this study underpins the correlation of IP law, ethics, morality, science and technology. It further adopts the theories of legal positivism to evaluate the prevailing conventional definitions of 'inventor' and 'inventiveness' and securities extended by patent law. It further draws in normative ethical theories to approach the ethical and moral implications of inventorship of machines. Last but not least, this study also adopts a socio-legal approach in order to comprehend how contemporary legal systems could employ modern technological advancements in a positive manner. This framework supports an extensive analysis of not only legal but also ethical, moral and technological dimensions of inventorship of machines, comprehensive analysis of both the legal and ethical dimensions of AI inventorship, directing this study towards proposing practical legislative reforms.

2. METHODOLOGY

With the aim of suggesting amendments to the Intellectual Property Act No. 36 of 2003 to uplift the patent law of Sri Lanka in a manner that the law integrates the global technological advancements into domestic law, this research attempts to study the controversial concept of 'inventiveness of machines' considering the legal and moral facades associated with it. A mixed method approach characterized by a fusion of research methodologies was adopted during this research in order to ensure a comprehensive investigation. A thorough examination of existing scholarly literature, legislation, case law and related resources was conducted to provide a robust theoretical foundation for the study. An array of domestic and international research instruments, judgements and legislation were studied. Furthermore, empirical research techniques were also employed while integrating qualitative and comparative research methodologies. Direct observations were made and firsthand experiences were gained on the innovation eco-systems and patent legislation of China and Sri Lanka

making the study largely backed by empirical data accumulated during the said course. These diverse research approaches were deliberately integrated to strengthen the study's depth and breadth while fostering a comprehensive analysis of the subject matter.

3. LITERATURE REVIEW

3.1 Artificial Intelligence: Definition and Evolution

While there is no universally accepted definition for AI, the generally accepted consensus is that 'AI denotes to the development of software or computer programs that can execute tasks which usually require human intelligence; such as machine learning or learning from experience, reasoning, understanding, identifying patterns, problem solving and many more (Copeland 2024). Watanabe (2021,) suggests that, the existence of a diverse range of AI technologies and their unpredictable advancements are the biggest hurdles in compiling and bringing AI under one classification. Nevertheless, scientists and scholars have been able to classify AI into two main categories; 1. Weak/Narrow AI and 2. Strong/General AI. Weak AI is usually designed to perform specific tasks, thus considered narrow and distinctive. Unlike weak AI, strong AI is designed to learn and think. Therefore, it possesses human-resembling cognitive capabilities ranging from answering a simple question to creating a patentable invention on its own.

In the last fifty years, Al has seen tremendous advancement from being able to play chess, to becoming the groundbreaking technology in self-driven cars (Zhi Shi and Zheng, cited in Stamatis 2019) And today, AI is identified as a subset of computer science which replicates and expands the intellectual abilities of human mind through computerized neural networks (Stamatis 2019). The origin and evolution of AI could be segregated into few key eras.

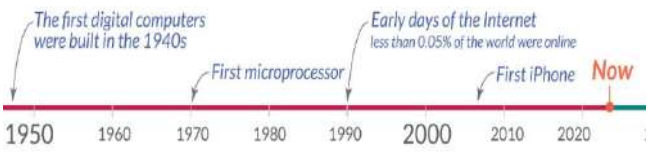

Figure. 1 Roser (2022), Evolution of AI

First Roots of AI (1950s-1960s): 'Alan Turing' is considered the pioneer in AI as he initiated the foremost effort of building an AI system in 1950 (Butterfield et al, cited in Greer 2022). But the earliest successful AI system 'Theseus' was designed by Claude Shannon in 1950. 'Theseus' was a remote controlled mouse, capable of remembering a path and finding its way out of a maze (Klein, cited in Roser 2022). Even though such a system was built in the early 1950s, the term 'Artificial Intelligence' was first introduced in 1956 during Dartmouth Conference by John McCarthy, where scientists gathered to discover possibilities of inventing a technology that could mimic human intellect (Greer 2022). A program called 'The logic theorist', designed to mimic the problem solving skills of humans presented at 1956 Dartmouth Summer Research Project on Artificial Intelligence (DSRPAI) is considered to be the first AI program. However, early research was centered on symbolic reasoning and systems were built to crack predefined problems using predefined rules.

Knowledge-Based Systems (1970s-1980s): In early 1970s, research on AI shifted its course towards knowledge based systems, which employed pre-recorded guidelines and knowledge databases to solve problems. Computer systems capable of replicating human proficiency in specific fields became popular in this period.

AI Winter – Decreased Focus (1990s): Beginning of the 1990s brought lack of enthusiasm, technological limitations and decreased monetary backing for research, impeding AI's advancement. But the late 90s saw much needed resurgence in research. For example, IBM developed a computer program for playing 'Chess' named 'Deep Blue' in 1997 (Watanabe 2021,). Founded in as early as 1911 as a Computing-Tabulating-Recording (CTR) company, The International Business Machines Corporation or IBM is the largest industrial research organization in the world and it holds the record of being the generator and owner of most annual US patents by a business for a period of 29 consecutive years from 1993 to 2021 (Bellis, 2020). IBM made history when 'Deep Blue' succeeded in defeating human chess world champion, grandmaster Garry Kasporov in a game of chess, boosting the enthusiasm in AI research (O'Malley, cited in Robinson 2021). According to Anyoha (2017),

the first successful speech recognition software built by Dragon Systems instigated on Windows could be considered as a giant leap in the history of AI.

Machine Learning Renaissance (2000s): The dawn of new millennium was fueled by escalated computing power. It resulted in rocketing improvements in machine learning to a revival of curiosity in AI. AI systems were designed to copy and mimic human skills by implementing specific algorithms which permit machines to learn and adjust to given conditions and solve problems during this period (Stamatis 2019,). Development of techniques like neural networks, fuzzy systems and genetic algorithms contributed to further advancements in image and speech recognition in this era. (Neural networks are extensive sets of artificial neurons, corresponding the structural and operational characteristics of biological neurons while fuzzy systems construct algorithms relying on computational 'improbabilities/uncertainties' to learn and make decisions and genetic algorithms are used to replicate the progression and transmutation of genetic material themselves to generate a persistently changing computerized intelligence network (Maries Scarlat 2012)). The following figure exhibits the hype and descend of AI technology from the 970s to the 21st century.

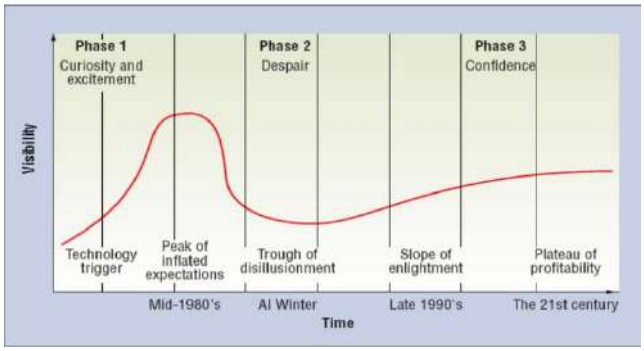

Figure. 2: Smith (2006), The Hype Cycle and AI Winter

Rapid Advancement – Everyday Usage (2010-2020): Time from 2010 onwards started showing a remarkable expansion in AI technologies. Applications of AI became endless and cohesive with human life. With the aim of automating and alleviating everyday life, scientists and researchers were able to develop better technology that could stimulate human intelligence enabling machines to solve problems in real-world processes (Stamatis 2019). Virtual assistants such as 'Siri', 'Alexa' and 'Chat GPT', speech recognition, image recognition, recommendation systems, smart phones, computer vision and autonomous vehicles are few examples for widespread common applications of AI (Smith et al., 2006).

During this time, AI promptly steered the man kind towards an advanced, automated and autonomous direction, where computers became capable of inventing on their own (Abbott, cited in Jain 2021). Thus, conversations and debate about responsible AI development and deployment gained prominence within this period.

Ongoing Advancements and Emerging Ethical Conserns (2020 onwards): According to Jain (2021), today's AI technology possesses the ability of accomplishing tasks in just minutes which were beyond human capability for the last 1000 years. Artificial intelligence transcends just science fiction as it demands collaborative research in numerous fields such as cognition or understanding, algorithms, linguistics, statistics, neuroscience, law, ethics and beyond. AI has become a matter with its own comprehensive intellectual challenges at presents as it cannot be narrowed down to limited applications or to particular genetic constructions (Smith et al., 2006). Hence, the mounting impact of AI has given rise to legal, ethical and moral concerns related to human privacy, partiality, transparency, and specially job displacement due to automation, at present.

3.2 An overview of patent law

Patent law provides inventors a mechanism to safeguard their rights and advantage from their inventions while contributing to economic growth by encouraging innovation. It also seeks to strike a deliberate balance between the interests of inventors and general public. Therefore, understanding and studying the core principles of patent law is essential for all stakeholders affected by patent rights.

A 'Patent' is an exclusive right awarded for an invention that is related to a product or a process which reveals an innovative method of performing a task or provides an

original technical solution to an existing problem (Marsoof, Kariyawasam and Talagala, 2020). A patent is usually granted for a period of 20 years. It permits the inventor a monopoly to produce, manufacture, trade, import and gain financial benefits for the allowed period of time. Simultaneously, it holds the inventor under obligation to reveal all methodical and technical details related to the invention on the lapse of patent time. Patents foster innovation and encourage technological advancements by serving as a deterrent against unlawful imitation of original work and by allowing inventors reap the harvest of their intellectual labor (Stamatis, 2019).

The treaties laid out by World Intellectual Property Organization (WIPO), the Agreement on the Trade Related Aspects of Intellectual Property Rights or TRIPS laid out by World Trade Organization (WTO) are key treaties that set out the primal international standards with regard to the protection of all intellectual property including inventions and patents (Marsoof, Kariyawasam and Talagala, 2020). According to Article 27.1 of TRIPS, there are three major requirements of patentability. An invention should be 1. new (novelty), 2. should consist of an inventive step (non-obviousness) and 3. be useful in an industry (industrial applicability). The inventions that fulfill the above criteria are considered to be eligible for patents. Particular subject matters such as, abstract ideas, scientific theories or discoveries, laws of nature, certain medical treatment, etc. may not be eligible for patent protection. Patent rights are generally territorial in nature, therefore the scope of patentable subject matter may differ from jurisdiction to jurisdiction (Hewage, 2015). Subsequently, landmark judicial decisions across various jurisdictions have made a significant impact in shaping the general standards of patentability. Some of these cases have redefined patent eligibility criteria, challenged the patentability of abstract ideas and also provided clarity on the scope of patentable subject matter. A notable example for such landmark judgement is *Diamond v. Chakrabarty* [1980] in which the US supreme court ruled out that living organisms which are genetically modified could be patented, expanding the patentable subject matter. In *Bilski v. Kappos* [2010], the US supreme court addressed the patentability of business techniques setting out new standards of patent eligibility. Reshaping the scope of biotechnology patents, in the case, *Association for Molecular Pathalogy v, Myriad Genetics* [2013], it was ruled that naturally occurring DNA sequences are not patentable. *Enfish, LLC v. Microsoft Corp.* [2016] could be recognized as a case which provided clarity on the patent eligibility of software related inventions. Indian judgements such as *Vifor International Ltd. v. MSN Laboratories Pvt. Ltd* [2021], *Allergan Inc v. The Controller of Patents* [2023], *Novartis AG v. Natco Pharma Limited* [2023] etc. have helped clarify and broaden the scope of patentable subject matter. Furthermore, European cases also have made a profound impact in reshaping European IP law covering not only patents but copyrights, industrial designs and trademarks as well (Heath and Sanders, 2012, p.90). These landmark judgements have not only influenced national and regional patent systems but also emphasized the importance of fostering innovation while maintaining the balance between patent laws and public interest. It could also be noted that, the global patent ecosystem has undergone significant transformation in recent years influenced not only by written law but also by landmark judicial decisions.

3.3 Intersections between patent law and artificial intelligence

When it comes to the connection between patent law and AI, there are multiple legal, ethical and technological aspects that should be taken into account. Therefore, the degree of human contribution in the perception of 'inventiveness of AI' should be carefully considered and understood in order to determine why, whether, or how the prevailing legal contexts should accommodate the interests generated by AI.

The traditional concept of 'inventiveness' is closely associated with human intelligence, imagination and creativity. The conventional 'inventor' is considered to be a natural person and is bestowed with patent rights. The general perception is that, there should be restrictions on patents, seeking to proclaim rights over certain living or biological materials, laws of nature, specific groups of software, etc. (Stamatis, 2019). But the emergence of AI has posed much dilemma about the traditional concept of inventiveness as AI systems have gained the ability to invent autonomously without human intervention. This dilemma revolves around whether AI systems should be perceived as inventors or if recognition should be

accredited to human operators, programmers or a combination thereof.

The prevailing patent legal frameworks mandate naming of a human inventor when claiming patent rights. In the latest judgement on DABUS, in *Commissioner of Patents v. Thaler* [2022] the full Australian federal court ruled out that an 'inventor' could only be a natural person (O'Callaghan and Shueard, 2022). This has led to much conversation on whether/how and why patent law should accommodate inventions by machines in patent law. Jain (2021) classifies AI related inventions in to two groups; 1. cases in which AI assists humans to invent, and 2. cases in which AI independently invent without human intervention. Though artificially intelligent, machines or AI cannot own or possess property including the intellectual property. The question lies within; if AI cannot own property then who will? Who will own and benefit from the monopolistic rights generated by a patent? This special situation involves several relations of ownership such as AI's owner, developer, user, data supplier and investor depending on their contribution to the creation of invention (Jain, 2021).

If the law does not address the predicament of inventiveness of AI, it would potentially lead to non-claiming of patent rights which would have undue impact on financial benefits expected under patent law (Watanabe, 2021). Scholars suggest distinct ways to address this issue. Many suggest that, a patent application would face potential voidness if either a natural person or an AI system exclusively claims patent rights as the inventor (Watanabe 2021,). A rational and realistic way to determine the ownership of AI is to decide on the contractual terms entered between stakeholders such as owner, programmer, user, data supplier, investor, etc. (Jain, 2021). Moreover, AI created inventions fulfill the traditional interpretation of inventiveness and its statutory requirements by designating minimally a single human as an inventor (Robinson, 2021).

Determining precisely where AI fits within traditional definition of inventor has become a challenging task due to the dynamic nature of both law of patents and AI technology. Fortunately, it is still not possible for AI to function completely autonomously without the assistance of humans (Watanabe, 2021). But one cannot predict the exact time frame that AI will take to surpass human intervention. Therefore, the touch of human intervention shall be maintained all times during the patenting process of inventions by AI.

4. DATA ANALYSIS

4.1 Patent eligibility of AI

When patent eligibility of AI is concerned, it should be carefully assessed whether such inventions pass the parameters of novelty, non-obviousness and industrial applicability.

The requirement of novelty functions as the key criterion in distinguishing the margin between inventive creations which genuinely contribute to society and the ones that simply attempt to replicate existing inventions (Marsoof, Kariyawasam and Talagala 2020). The novelty requirement of inventions of AI mainly depend on the inventive process used by AI algorithms. Absence of novelty may arise when the employed algorithm lacks diversity in its outputs or depends on similar datasets, while the algorithms which integrate variability are more likely to create original inventions (Fraser, 2016). But AI is likely to create original creations as it has the ability to review prior art rapidly and precisely more than any human inventor.

Secondly, an invention should comprise of an 'inventive step' to be able receive patent protection. The test of PHOSITA has been accepted in numerous jurisdictions as the parameter of deciding inventive step or non-obviousness (Lemley cited in Jain, 2021). According to PHOSITA test, an invention involves an inventive step if it is not obvious to a Person Having Ordinary Skills in the Art. An invention could lose patent eligibility if a PHOSITA discovers obviousness between the invention and prior art. In terms of feasibility, it is impractical for any human being to have and hold all knowledge about the patent seeking subject matter (Jain, 2021). With its ability to evaluate and process more information than a human, it would be realistic for a machine to pass the PHOSITA test than a human inventor. Scholars suggest that, there may be a need to reevaluate the parameters of ordinary skilled person and obviousness, when such

extremely large computational power is considered (Fraser 2016).

Thirdly, an invention is considered patentable if it could be applied or used in an industry or a commercial setting (industrial applicability/utility requirement). Industrial applicability is often interpreted in a board manner and does not necessarily mean that an invention has to be commercially exploited to be patentable (Jain, 2021). But, the invention should not be completely theoretical yet should showcase an amount of practical utility.

However, the existing legal frameworks do not explicitly create limitations on the individual who completes the task of inventing. It rather considers whether an invention fulfills the major requirements of patentability. Therefore, AI generated inventions are not explicitly disqualified by conventional patent law. In theory, such inventions could obtain patent rights as long as they meet the legal requirements.

4.2 Ethical considerations

Challenges are being posed on the conventional perceptions of 'inventor and inventiveness', as AI technology becomes more important in the course of innovation day by day. It is continuing to raise confrontations not only legally, but also morally and ethically. AI algorithms are becoming more useful and dominant in daily life, even if we do not always recognize them to be AI. However, when those algorithms start functioning intelligently like humans, the AI also should take over social responsibilities that are associated with such intelligence (Bostrom and Yudkowsky, 2014) Partiality, discrimination, transparency, security, privacy, transparency, accountability and job displacement could be recognized as the key ethical considerations generated due to inventiveness of machines.

Partiality and discrimination are two major moral challenges posed by AI. Artificial intelligence has the potential to take on partiality or bias in the data sets that were used to train it, which may lead to discrimination in fields like image recognition, loaning and employment (George and Walsh, 2022). Security of personal information and invasion of privacy is another significant apprehension arising from AI's tendency for processing extensive amounts of data. AI algorithms with their data hungry nature, could possibly misuse personal information and cause privacy breaches (Stahl et al., 2023). Such breaches could pose serious threats to personal security and privacy of billions of people across the world.

AI systems are generally complicated and obscure. Therefore, it is challenging for human beings to fully understand the rationale behind certain actions of AI. This might lead to lack of transparency in AI driven systems causing issues in accountability particularly in areas like healthcare, banking and autonomous vehicles (Stahl et al., 2023). Simultaneously, AI has raised concerns about job displacement on a large scale, as AI's capacity to exceed human intellect and speed is moving the world towards automation.

Scholars warn that, these ethical considerations could create long-term effects on human society in future (Chikhaoui and Saghir, 2020). Addressing these concerns calls for a multidisciplinary approach between patent law, science, technology, ethics, policy making as well as society in order to ensure that the benefits of technological advancements are well balanced with ethical values and social welfare.

4.3 International perspectives

Patent rights are territorial in nature. Even though there are international agreements laying out minimum standards of protection, patent laws vary from jurisdiction to jurisdiction. According to scholars there is almost no internationally accepted laws or regulations with regard to inventions created by AI and most jurisdictions necessitates patent applicants to name a human inventor to safeguard the rights of natural persons (Abbott, 2019). Meanwhile, some countries like South Africa and Australia have already begun to accept the concept of inventiveness of machines within their jurisdictions.

South Africa made history when it granted a patent for a non-human inventor for the first time on 28th July, 2021 (Nissanka, 2022). This patent was granted for an invention autonomously created by the AI system DABUS (Device for the Autonomous Bootstrapping of

Unified Sentience) developed by Dr. Stephen Thaler. Though South Africa granted a patent attributed to an AI inventor, the South African courts have not yet decided whether an AI network could be considered as an 'inventor' under South African Patents Act No. 57 of 1978.

In the case of DABUS, Dr. Thaler initially applied for patent rights for DABUS in a number of countries but the applications got turned down due unavailability of a human inventor. For instance, in the case *Thaler v. Commissioner of Patents* [2023] NZHC 554, the High Court of New Zealand rejected the application ruling that the 'inventor' is limited to natural persons (Halberg, et al., 2023). Quite lately, in winter 2023, the supreme court of UK unanimously ruled that UK law does not permit an AI to be named as an inventor (Assmus et al., 2024).

Meanwhile in the case *Thaler v. Commissioner of Patents in Australia* [2021] an Australian court recognized DABUS to be the inventor (Zipper, 2022). Even though this groundbreaking judgment was the first of its kind to recognize AI as an inventor, it was later ruled out that AI does not serve the purposes of 'inventor' under patent law. In the latest ruling of *Commissioner of Patents v. Thaler* [2022], the full federal court of Australia unanimously held that a non-human agent cannot be named as an inventor for the purpose under the Australian Patents Act 1990. The full Court determined that only a natural person is capable of being named as an 'inventor', effectively shutting down the concept of AI-led patent applications in Australia and DABUS judgements have made significant implications in the field of patent law and have raised imperative policy questions about AI created inventions (O'Callaghan and Shueard, 2022).Simultaneously, UPSTO - United States Patent and Trademark Office, US federal courts, EPO-European Patent Office and FPC-German Federal Patent Court have ruled out that artificial intelligence cannot be allowed to be considered as an inventor (Assmus et al., 2024).

The above cases concerned, harmonizing AI related patent laws internationally deems to be a demanding task. But it is important to reconsider the existing parameters of patentability and appropriate laws put in place as AI is evolving at a rapid pace comparing to the intelligence of human kind. It will also be beneficial in incentivizing AI related innovation and in terms of economic aspects associated patent law.

4.4 Sri Lankan perspective

Sri Lanka's legal framework on patents is governed by the part IV of the Intellectual Property (IP) Act No. 36 of 2003. The act came into effect on 1st January 2025 repealing the previous law: Code of Intellectual Property Act No. 52 of 1979. Sri Lanka is also a party to several international agreements regarding the protection of patent rights. Being a founding member of WTO Sri Lanka is a party to TRIPS agreement endorsed by WTO. Sri Lanka is also a party to the Paris Convention on the Protection of Industrial Property (Paris Convention) endorsed by WIPO. According to Marsoof, Kariyawasam and Talagala (2020) TRIPS and Paris Convention mandate its member states including Sri Lanka, only to give effect to the 'minimum standards' laid out in the agreements. The enactment of IP Act No. 36 of 2003 aimed at aligning the country's IP laws in accordance with its commitment to TRIPS and was crafted following the 'model laws' endorsed by WIPO (Hewage, 2015).

Patent regulations in Sri Lanka's IP act do not necessarily state any legal provision on 'inventiveness of AI'. The Act does not explicitly recognize nor excludes inventiveness of machines. Article 62(1) defines 'invention' as an idea of an inventor which permits in practice the solution to a specific problem in the field of technology. According to Article 62(2), the act recognizes that an invention could be related or could relate to a product or a process. Article 62(3) excludes inventions that cannot be patented under Sri Lankan Law such as; discoveries, scientific theories, mathematical, methods, living beings other than transgenic micro-organisms, biological/microbiological processes that produce living beings, business methods, mental acts, methods of treating/diagnosing on human or animal bodies, etc.

Even though section 62(3) does not explicitly exclude AI generated inventions from patentability, section 62(3) (f) states that certain inventions may be prevented from commercial exploitation within Sri Lanka if their use poses a possible danger to public order, morality, life, health or the environment. It could be asserted that inventions of AI may be obliquely refrained from patenting if their use falls under the context of this sub

section 62(3)(f). Sections 63 – 66 states general provisions on novelty, inventive step and industrial applicability. Article 67 mandates that right to a patent shall belong to its inventor or joint inventors. But the act does not interpret whether the inventor should be a live person or otherwise.

Sub-section 69(2) holds much significance as it provides that 'where an employee whose contract of employment does not require him to engage in any inventive activity, makes in the field of activities of his employer, an invention using data or means placed at his disposal by his employer, the right to the patent for such invention shall be deemed to accrue to the employer, in the absence of any provision to the contrary in the contract of employment'. According to sub-section 69(2), patent rights shall be vested in the hands of employer, in cases where an employee, who is not mandated involve in inventing activities, invents something using employer's data or resources. If the term 'employee' is interpreted in the context of 'AI or a machine' it is affirmative to state that patent rights for an invention generated by AI shall belong to its owner or employer under Sri Lankan legal context. Article 70(1) mandates naming of an inventor in the patent. As this article uses the terms 'he, him and his', it could be determined that the act requires the inventor to be a living person.

IP Act No. 36 of 2003 does not explicitly address or accommodate the concept of inventiveness of machines in Sri Lankan law. Simultaneously the act neither excludes the concept unambiguously. Even though current regulations may not provide specific guidelines or criteria regarding AI created inventions, it is affirmative that the prevailing regulations could be interpreted in a broad manner if any such need arises in future.

5. DISCUSSION

"Innovation is born out of necessity."
(Chesbrough 2005)

If someone attempts to explain a person born in last couple of decades, that the very first computers did not have access to internet, they will probably be surprised and ask what people used computers at all (Watanabe, 2021). The main purpose of early computers was to aid humans work better and faster. Computers evolved rapidly from generation to generation and new era of technology dawned with the development of artificial intelligence.

The mankind has come a long way from the first industrial revolution. It could be argued that the human race is sitting on the verge of fourth industrial revolution which will be unlike any of the previous three revolutions (Chowdhury, 2021). Scientists have developed software that uses ideas from 'Darwinian's theory of evolution' such as 'the survival of the fittest' to construct AI algorithms to that could improve from generation to generation without human interference (Chowdhury, 2021). Now that AI has the capability of functioning and inventing on its own, ignoring the intervention of humans in the process could result in unanticipated consequences where AI might eventually supersede nature and human beings posing significant threats to mankind. Hence, policy-makers should constantly observe and analyze the dynamic nature of patent law, AI technology and their potential impacts to guarantee that the core foundation of patent law is conserved (Fraser, 2016).

International agreements like TRIPS and Paris Convention, lay out only the minimum standards to defend IP. They do not mandate member states to blindly follow the laid out legal frameworks. TRIPS allows WTO members with flexibility to maneuver and customize their patent laws according to their distinctive legal frameworks and national interests (Marsoof, Kariyawasam and Talagala, 2020). Countries are allowed with freedom to amend their own laws in accordance with new technological advancements the world is going through. And the existing international agreements do not barricade if a country is willing to accept the concept of 'inventiveness of machines' into their respective legal systems. Even though laws, rules and regulations on 'patentability of AI' are not yet clearly established on a global scale, countries may alter and improve their residential legal systems to clarify the confusion caused by AI inventors affording their unique domestic interests.

When it comes to Sri Lanka, the IP Act No. 36 of 2003 or any other law neither recognizes nor forbids the inventiveness of machines. With respect to economic

interests, Sri Lanka also cannot completely deviate from the rest of the world. With the world slowly addressing the novel concerns raised by 'inventiveness of machines', it would be a clever move for Sri Lanka to amend the patent law to clarify its national opinion and provide for patentability of AI created inventions under stringent conditions (Nissanka, 2022). Such action would help avoid possible challenges and confusion arising from rapidly advancing AI technology in future.

6. RECOMMENDATIONS

After a thorough examination of extensive research and literature, it could be recommended that inventiveness of AI shall be accepted under clear and stern conditions in patent law including in Sri Lanka. It is suggested that the prevailing patent laws should recognize the concept of 'collaborative inventiveness' of human and AI, and the natural person or the entity consisting of natural persons who uses AI to create or invent a patentable technology alone with the AI inventor should be considered as 'collaborative owners' of patent. A patent should not be granted if there is not at least one natural person mentioned when filing an application as AI cannot practically own property rights or held liable before a court. The human owner shall be allowed to own, possess and make use of the rights generated by such patent. At the same time, the human owner shall be held liable to fulfill the disclosure requirement after the lapse of time granted by patent and he shall be held vicariously liable for any illegal situation (unlawful act or omission) arising from AI. If proven, such vicarious liability should be extended to the creator of AI if an unlawful act or omission is caused due to an intentional act of the creator of AI. Subsequently, the definition of 'invention' should be amended to cover the inventions by AI. (In Sri Lankan law section 62(1) of IP Act No. 36 of 2003). Furthermore, the requirements of novelty, non-obviousness and industrial applicability should be thoroughly considered before granting a patent to avoid accumulation of impractical and worthless patents. Last but not least, the parameters of PHOSITA should be reconsidered and AI should be considered as a PHOSITA in cases of AI related patent applications.

7. CONCLUSION

"The foundation of human ingenuity lies in the faith that there is always an easier way that something can be done." (Sahal, 1985,)

The traditional notions of inventiveness and patentability are constructed around human inventors. The novel conception of 'inventiveness or machines or AI' has posed several challenges and triggered much debate in the patent law landscape on a global scale. Invention via AI is the future of innovation. The machines, the technology that build machines and the intelligence of machines are evolving and advancing at a rapid speed, the human kind never imagined of. Therefore, the issues and complications caused by non-human inventors to the well-established principles of patent law cannot be underrated or entirely disregarded (Saw and Chan, 2023).

As the concept of patentability of inventions by AI is quite novel, the patent law regimes of many countries including Sri Lanka are not equipped or prepared yet to address how, why or whether they should allow AI inventors into their legal systems. We are still at an early juncture and it is too early to arrive at a conclusive decision on the pros and cons of AI technology. However, regardless of our preferences, sooner or later, the future of innovation will start relying on inventions created by AI (Schuster, 2018). Therefore, the laws should be ready and in line to afford the future advancements of AI in order to uphold the human control over machines.

This comprehensive study tried to initiate a timely conversation on the challenges posed by inventiveness of machines highlighting their legal, ethical and technological components. Keeping the contribution of AI technology to economy in mind, this research concludes that, the concept of 'collaborative inventiveness of AI and human' should be recognized within the existing regulatory frameworks on patents. Thus, the rights and duties generated by a patent for an invention of AI should be accredited on both the AI and natural persons that utilize AI to develop such patentable inventions.

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SECONDARY SCHOOL ADOLESCENTS' KNOWLEDGE OF CORRUPTION IN NIGERIAN SOCIETY: IMPLICATIONS FOR COUNSELLING AND VALUE REORIENTATION

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ABSTRACT

Corruption is a global phenomenon whose degrees of prevalence as well as the measures being taken to address it vary from one nation to another. Nigeria is not an exception in the "struggle" with corruption. The aim of this study therefore was to investigate secondary school adolescents' knowledge of corruption in Nigerian society with its implications for counselling and value reorientation in society. It examined secondary school adolescents' perspectives on practices constituting corrupt practices in Nigerian society. The study further determined secondary school adolescents' attitudes towards corrupt practices in Nigerian society. It also examined their perspectives on how corrupt practices can be curbed in Nigerian society. The study adopted a survey design. The population of the study comprised all the senior secondary school students in Osun State, Nigeria. The sample size comprised 200 senior secondary school students selected across Osun Central senatorial district in the State, using a simple random sampling technique. The Researchers developed a questionnaire titled Adolescents' knowledge of Corrupt Practices Assessment Questionnaire (AKCPAQ) which was used to collect data for the study. Percentages, mean, standard deviation, ranking and weighted mean were used to analyse the data. The results showed that secondary school adolescents in Nigeria lack adequate knowledge of practices that constitute corrupt practices in society. Also, majority (84.0%) of the secondary school adolescents expressed unfavourable attitudes towards known corrupt practices. The results further showed that corrupt practices in Nigeria can be ended if people at all levels of authority discharge their responsibilities with integrity and government caters for the citizenry as it should. The study recommends among other things that the sensitization of secondary schools' adolescents on behaviour and practices that constitute corrupt practices in society.

KEYWORDS: Value, Corruption, Adolescents, Nigeria, Secondary Schools

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1. INTRODUCTION

The functionality of any society requires having individuals or group of people either selected through electoral or any other acceptable process to steer the affairs of that society. For these selected or elected individuals to get the common goals of the society or nation achieved, the commonwealth that society or nation must be judiciously managed for the benefit of all. However, when the individuals saddled with leadership responsibility of the nation begin to take advantage of their position to engage in illegal, dishonest, unwholesome acts while rendering their services, the development is usually described as corruption (Uche, 2014). The Department for International Development (2015) described corruption as the misuse of resources or power for private gain. Transparency International (2021) defined corruption as the abuse of entrusted power for private gain. According to this global body, corrupt practices or behaviours manifest in many forms which include public servants demanding or taking money in exchange for services; politicians misusing public money or granting public jobs or contracts to their sponsors, friends, families; and corporations bribing officials to get lucrative deals.

The reports of the second survey of the United Nations Office on Drugs and Crime (UNODC) on corruption indicated that 30.2 percent gave a bribe or were asked to give a bribe by a public official among Nigerian citizens who had at least one contact with a public official in the 12 months prior to 2019 survey (UNODC, 2019). It is however important to stress that corruption is not peculiar to Nigerian society alone. It is correctly described as a global phenomenon with respect to developmental status of the nation whether advanced, primitive, modern or traditional (Moyosore, 2015). Nevertheless, the prevalent rate and its adverse impacts on the developing nations like Nigeria call for concern. Despite the Anti-Corruption campaign and measures of the current administration of President Muhammadu Buhari commenced in 2015, the available data indicate that not much success has been achieved. The score of Nigeria in 2020 Corruption Perception Index (CPI) as published by Transparency International still indicates that Nigeria is among the highly corrupt nations, while Sub-Saharan Africa is the lowest performing region on the CPI (Transparency International, 2020).

The global effort towards completely getting rid of various dimensions of corrupt practices stem for its attendant adverse effects on development of nations and the general well-being of citizens in their respective country. The detrimental impacts of corruption in society permeate all facets of human lives. According to UNODC (2020), corruption hinders development, worsens income inequality among the populace, reduces both domestic and foreign investment, culminates in inefficient allocation of public funds, lowers public sector services, and also deprives citizens of access to public services.

While the adverse effects of corruption in Nigerian society is widely acknowledged, empirical findings do not suggest that there is a significant level of agreement on the specific behaviour or practices that constitute corruption in Nigeria. For instance, in a study carried out by Olawuyi, Ajayi and Uyanne (2018) to examine corrupt practices in the educational system among university students and staff, it was reported that both students and staff agreed that promotion of teachers or lecturers based on loyalty to constituted authority at the expense of meritocracy, diversion of budget or other resources allocated to schools, diversion of funds meant for procurement of materials and construction of facilities by few individuals in authority, and insistence on selecting the head for a particular position from a certain part of local government, state or geopolitical zone constitute corrupt practices. They however differed on practices such as acceptance of gratification from parents to ensure access to schools, awarding good grades to students that they do not merit, adjusting criteria for admission to favour certain segment of individuals, approval of school projects for personal and political interest rather than educational needs, exposing examination questions or tests to high-paying or influential candidates before the actual commencement of examination, selection of accreditation team based on nepotism instead of merits and professionalism. While students considered these practices as corruption, the staff perceived them as normal in the system. While the work of Olawuyi,

Ajayi and Uyanne (2018) remains an important contribution to knowledge, the work did not specifically examine secondary school adolescents' knowledge of corrupt practices in Nigeria as well as their attitude to them. The need to explore this area however can hardly be overemphasised.

Asiyai (2020) also reported examination malpractices, collection of illegal charges by principals, extortion of money by teachers and withholding of textbooks allocated to schools, favouritism, irregular movement of teachers during school hours and inducement to secure admission as prevalent corrupt practices found in secondary schools in Edo State. The administrative strategies for curbing corruption in secondary schools as identified by Asiyai (2020) include good remuneration for teachers, formation of anti-corruption clubs, and proper value orientation. Adesina and Oluyemi (2012) also reported that the majority (84.3%) of the respondents in their study were aware of the prevalence of corrupt practices in society while 5.0% shared a contrary opinion. Useful as the findings of Asiyai (2020) as well as that of Adesina and Oluyemi (2012) are, a study specifically focused on adolescents' knowledge of corrupt practices and their attitude to them would be a very relevant addition to the wealth of information on corruption in Nigeria and globally.

In the same vein, Olayiwola & Ajayi (2014) argue that attitude, behaviour and feelings are interrelated terms. Similarly, Hayes, (2010) defines attitude as an individual's prevailing tendency to respond either favourably or unfavourably to an object (person or group of people, institutions or events). In addition, Gatti, Paternostro and Rigolini (2003) report that 75% of individuals in their study sample agree that the acceptance of bribes as an action that is never justifiable. This outcome therefore is an indication of unfavourable attitude towards corrupt practices. Moreover, findings of UNODC (2019) on corruption in Nigeria show that citizen's attitudes about the acceptance or refusal of bribes can influence the behaviour of others when faced with request for bribes. These studies, important as they are, did not cover secondary school adolescents' knowledge of corrupt practices as well as their attitude towards them. The researchers opine that this is a major research gap that is necessary to be filled because, among other reasons, secondary school adolescents constitute a very significant segment of a nation's population.

1.1. Statement of the Problem

While it is widely acknowledged by all and sundry that corruption impedes the development and progress of any society, not many individuals easily come to term on behaviour and practices that constitute corrupt practices. Experiences in contemporary Nigerian society have shown that the nation's previously cherished values such as good character, good family name etc., are fading out at a very alarming rate with vices gaining prominence rapidly. Consequently, children and youths who are usually referred to as the future of our nation are already part of the nation with deteriorating values. With this ugly development in society, cleansing the mind of the youths, who are the future generation of the country, becomes a herculean task; nonetheless not impossible to achieve. However, these occurrences and the need to secure the future for the incoming generation, call for drastic steps with all hands being on deck.

One of the ways of preparing these youths for future leadership is by ensuring that they do not imbibe the culture of corruption that is fast gaining ground in the country. To do this effectively, it is imperative to find out if these youths have the correct conception of corrupt practices in the country, correct attitude towards corrupt practices in Nigerian society as well as the correct perspectives on how these corrupt practices can be eliminated.

1.2. Purpose of the Study

The purpose of this study is to

1. examine secondary school adolescents' perspectives on practices constituting corrupt practices in Nigerian society.
2. determine secondary school adolescents' attitudes toward corrupt practices in Nigerian society.
3. examine secondary school adolescents' perspectives on how corrupt practices can be stopped in Nigerian society

1.3. Research Questions

For this study, it is necessary to answer the following questions:

1. What are the practices that constitute corrupt practices in Nigerian society from the secondary school adolescents' perspectives?
2. What is the secondary school adolescents' attitude towards known corrupt practices in Nigerian society?
3. What are the secondary school adolescents' perspectives on how corrupt practices can be ended in the Nigerian society?

2. METHODOLOGY

2.1 Research Design

This study employed in the survey research design. It allows the researcher to obtain information from a representative sample of a particular population on a phenomenon of interest to the researcher. Since the researcher have no intention to manipulate any variable in the study, the survey design was found appropriate for a study of this nature.

2.2. Participants

The study participants were 200 public senior secondary school adolescents selected using a simple random sampling technique.

2.3. Instrument

The instrument titled Adolescents' knowledge of Corrupt Practices Assessment Questionnaire (AKCPAQ) developed by the researchers were used to collect data for the study. AKCPAQ consists of 36 items of which items 1-16 measured practices that constitute corrupt practices in Nigeria, items 17-26 measured attitudes towards corrupt practices, while the rest of the items concentrated on how to stop corrupt practices with a four-point Likert scale response format of Strongly Agree, Agree, Disagree, Strongly Disagree. The instrument AKCPAQ reported a moderate Cronbach's Alpha reliability coefficients of 0.68 when the instrument was pilot-tested.

2.4. Data Collection Procedure

The researcher visited the selected secondary schools in Ife North Local Government Area of Osun State, Nigeria to seek permission to carry out the study. With the permission of the school authorities, questionnaires were administered to the students by the researchers assisted by three trained research assistants. The questionnaires were explained to the students before administering them, and all the completed questionnaires were retrieved from the respondents the same day, collated and coded for data analysis.

2.5. Ethical Considerations

The researchers received ethics approval for the study from the Research Committee of the Department of Educational Foundations of their institution. The participants in the study were well informed about the purpose, procedure and importance of the study. Participation in the study was voluntary and the participants were given the privilege of anonymity. All the data collected were kept confidential and stored securely for processing.

2.6. Analysis of Data

The data collected was analysed using descriptive statistical tools such as frequency and percentage, mean, standard deviation, ranking and weighted mean.

3. RESULTS

3.1. Secondary School Adolescents' Perspectives on Practices that Constitute Corrupt Practices in the Nigerian Society

Table 1 shows the distribution of the secondary school adolescent respondents that participated in the study by

Table 1: Distribution of the Demographic Characteristics of Adolescents by Gender, Age, Class and Discipline

Variables	Demographic Characteristics	N Participants	%
Adolescents by Gender	Male	95	47.5
	Female	105	52.5
	Total	**200**	**100.0**
Adolescents by Age	14-16yrs	161	80.5
	17-19yrs	33	16.5
	Above 19yrs	6	3.0
	Total	**200**	**100.0**
Adolescents by Class	SS1	80	40.0
	SS2	85	42.5
	SS3	35	17.5
	Total	**200**	**100.0**
Adolescents by Discipline	Science	82	41.0
	Arts	56	28.0
	Commercial	62	31.0
	Total	**200**	**100.0**

gender, age, class and discipline. In terms of gender 95 (47.5%) were male while 105 (52.5%) were female. In terms of age, 161 (80.5%) respondents were between 14-16 years, 33 (16.5%) were between 17-19 years while the age of 6 (3.0%) of the respondents were above 19 years. As shown in the distribution, most of the sampled adolescents were of 14-16 years of age. In addition, 80 (40.0%) of the respondents were in SS1 class, 85 (42.5%) in SS2 while 35 (17.5%) were in SS3 class. In terms of academic discipline, 82 (41.0%) in Science, 56 (28.0%) were in Arts, while 62 (31.0%) were in Commercial class.

Table 2: Secondary School Adolescents' Perspectives on Practices that Constitute Corrupt Practices in the Nigerian Society

S/N	Practices	Agree		Disagree	
		f	%	f	%
1	Promotion of workers based on loyalties to superior or authority at the expense of meritocracy.	159	79.5	41	20.5
2	Diversion of allocated budget or other resources without approval.	42	21.0	158	79.0
3	Diversion of funds associated with procurement of materials and construction of facilities by few individuals in authority.	88	44.0	112	56.0
4	Offering bribes or financial inducement to secure opportunity or avoid punishment.	45	22.5	155	77.5
5	Recruitment and promotion of workers without due process.	35	17.5	165	82.5
6	Accepting gratification from contractors before awarding government contracts.	56	28.0	144	72.0
7	Bypassing standard criteria for admission to favour certain segment of individuals.	27	13.5	173	86.5
8	Exposing examination questions or tests to high-paying or influential candidates before the actual commencement of exams.	27	13.5	173	86.5
9	Selection of inspection team members based on nepotism (man-know-man) instead of merits and professionalism	52	26.0	148	74.0
10	Allocation of salaries to ghost workers.	70	35.0	130	65.0
11	Promotion of friends or colleagues without regard to their qualifications.	37	18.5	163	81.5
12	Sexual harassment of junior female colleagues by superiors in offices	26	13.0	174	87.0
13	Illegal deduction of staff salaries by some government officials	22	11.0	178	89.0
14	Unnecessary absence from work without taking permission	28	14.0	172	86.0
15	Insistence on selecting the head for a particular position from a certain part of local government, state or geopolitical zone	144	72.0	56	28.0
16	Collection of illegal fees from motorists by law enforcement agents	27	13.5	173	86.5

The result in Table 2 shows that 79.5% of the secondary school students agreed that promotion of workers based on loyalty to one's superior at the expense of meritocracy constitute corrupt practice while 72.0% also considered insistence on selecting the head for a particular position from a certain part of local government, state or geopolitical zone as corrupt practice. However, 79.0% disagreed that diversion of allocated budget or other resources without approval is a corrupt practice. Also, 56.0%, 77.5%, and 82.5% disagreed that diversion of funds meant for procurement of materials and construction of facilities by few individuals in authority; offering bribe or financial inducement to secure opportunity or avoid punishment, and recruitment and promotion of workers without due process constitute corrupt practices. Similarly, 72.0%, 86.5%, and 86.5% disagreed that accepting gratification from contractors before awarding government contracts; bypassing standard criteria for admission to favour certain individuals, and exposing examination questions or tests to high-paying or influential candidates before the commencement of exams constitute corrupt practices. Likewise, 74.0%, 65.0%, 81.5% and 87.0% disagreed that selection of inspection team members based on nepotism instead of merits and professionalism; allocation of salaries to ghost workers; promotion of friends or colleagues without regard to their qualifications; and sexual harassment of junior female colleagues by superiors in offices were part of corrupt practices. Findings further show that 89.0% of the adolescents did not regard illegal deduction of staff salaries by some government officials as a corrupt practice; 86.0% disagreed that unnecessary absence from work without taking permission constitutes corrupt practice while 86.5% also disagreed that collection of illegal fees from motorists by law enforcement agents is part of corrupt practices in the Nigerian society.

3.2. Secondary School Adolescents' Attitude Towards Corrupt Practices in Nigerian Society The

result in Table 3 shows that the majority (84.0%) of secondary school adolescents expressed unfavourable attitudes towards corrupt practices while 16.0%

expressed favourable attitudes towards corrupt practices in the Nigerian society.

Table 3: Secondary School Adolescents' Attitude Towards Corrupt Practices in Nigerian Society

Nature of Attitude	Score Range	f	%
Favourable	10-15	32	16.0
Unfavourable	16-40	168	84.0
Total		200	100.0

The result in Table 3 shows that the majority (84.0%) of secondary school adolescents expressed unfavourable attitudes towards corrupt practices while 16.0% expressed favourable attitudes towards corrupt practices in the Nigerian society.

3.3. Secondary School Adolescents' Perspectives on how Corrupt Practices can be stopped in society

Table 4: Secondary School Adolescents' Perspectives on how Corrupt Practices can be stopped in society

S/N	Items	x	SD	Rank
1	People in authorities should rule with integrity	3.6	0.7	1st
2	Attitudinal change should be promoted among the citizens of the nation.	3.6	0.5	1st
3	Government officials and leaders should be made accountable for their actions and inactions	3.5	0.6	4th
4	Corrupt individuals should always be disgraced in society	3.5	0.7	4th
5	Stringent laws should be enacted for prosecuting corrupt individuals in society.	3.4	0.8	8th
6	Government should ensure that the citizens are well catered for.	3.6	0.7	1st
7	Life imprisonment should be made the consequence of corruption	3.0	1.1	10th
8	Every corrupt individual found guilty should be executed without delay.	3.4	0.8	8th
9	Corrupt official should be banned from any future position in the country	3.5	0.8	4th
10	Properties of the corrupt individuals should be confiscated to serve as deterrent to other.	3.5	0.8	4th
	Weighted Mean	**3.5**		

Result in Table 4 shows secondary school adolescents' perspectives on how corrupt practices can be stopped. Considering the weighted mean of 3.5 which is used as criterion of acceptance, it shows that the secondary school adolescents were of the opinion that corrupt practices can be stopped if people in authorities should rule with integrity (x = 3.6, SD= 0.7); through promotion of attitudinal change among the citizens of the nation (x = 3.6, SD= 0.5); when government well cater for the citizens (x = 3.6, SD= 0.7); when government officials and leaders are held accountable for their actions and inactions(x = 3.5, SD= 0.6); when corrupt individuals are always disgraced in society (x = 3.5, SD= 0.7); when corrupt official are banned from any future position in the country (x = 3.5, SD= 0.7), and when properties of the corrupt individuals are confiscated to serve as deterrent (x = 3.5, SD= 0.8).

4. DISCUSSION

The findings of the study showed that secondary school adolescents lack adequate knowledge about practices that constitute corrupt practices in Nigerian society. This is evident as the majority of the students disagreed that diversion of allocated budget or other resources without approval; diversion of funds associated with procurement of materials and construction of facilities by few individual in authority; offering bribe or financial inducement in order to secure opportunity or avoid punishment; recruitment and promote of workers without due process; accepting gratification from contractors before awarding government contracts; bypassing standard criteria for admission to favour certain segment of individuals constitute corrupt practices. Most students only agreed that promotion of workers based on loyalty to one's superior at the expense of meritocracy and insistence on selecting the head for a particular position from a certain part of local government, state or geopolitical zone constitute corrupt practices in the society. This finding is consistent with findings of Olawuyi, Ajayi and Uyanne (2018) that suggest that students expressed inadequate understanding about practices that constitute corruption in the educational system.

The study revealed that majority (84.0%) of secondary school adolescents expressed unfavourable attitudes towards known corrupt practices. This outcome is

expected as most of the citizens do condemn the act of corruption due to its adverse implications. Nevertheless, not many students acknowledge that corrupt practices transcend embezzlement of public funds as many do involve in one form of corrupt practice or the other without understanding or acknowledging it. The finding corroborates those of Gatti, Paternostro and Rigolini (2003) that the majority of their respondents value the acceptance of bribes as an action that is never justifiable. This outcome is an indication of unfavourable attitude towards corrupt practices.

The findings of the study further stated that corrupt practices can be stopped if people in authorities rule with integrity; when attitudinal change among the citizens of the nation is promoted; when the government well caters for the citizens; when government officials and leaders are held accountable for their actions and inactions; when corrupt individuals are always disgraced in society; when corrupt officials are banned from any future position in the country, and when properties of corrupt individuals are confiscated to serve as deterrent. This outcome suggests good governance as an antidote of corruption in the Nigerian society. This finding is similar to what Asiyai (2020) reported as administrative strategies for curbing corruption in secondary schools, in which good remuneration for teachers, formation of anti-corruption clubs, proper value orientation topped the ranking. Measures such as payment of good remuneration to teachers is an indication of government prioritizing citizens' welfare and well-being while attitudinal change among the citizens of the nation could be ensured through measures such as formation of anti-corruption clubs and proper value orientation.

5. CONCLUSION

The study concludes that secondary school adolescents lack adequate knowledge of what constitutes corrupt practices in Nigeria. However, the students expressed unfavourable attitude towards practices that are known to be corrupt practices in the country.

6. RECOMMENDATION

Consequent upon one of the key findings of this study that secondary school students lack adequate knowledge of what constitute corrupt practices in Nigeria, and based on the fact that the importance of having adequate knowledge of what constitute corrupt practices cannot be overemphasised if adolescent students are to make informed decisions on this subject, it is recommended that a well-coordinated sensitization programme on what constitute corrupt practices in Nigeria should be incorporated into secondary school curriculum and be taught by teachers specially trained to anchor such programme. This programme should also place emphasis on the negative effects of not arresting the increasing prevalence of corrupt practices in the country. In addition, the said sensitization programme should be structured to educate secondary school students to be well behaved and patriotic. Secondary school teaching and learning outcomes should be assessed periodically and a testimonial should be issued to each student at the end of his/her secondary school education showing performance in terms of character, patriotism and comprehension of what constitute corrupt practices in the country. If secondary school adolescents can be successfully educated to be patriotic to the nation, it will go a long way in making them to have zero tolerance for corrupt practices before and when they step into leadership positions in the country.

An additional finding of this study, that majority of secondary school adolescents agreed that corrupt practices do not augur well for the generality of the citizens at the end of the day, is an indication that if these secondary school adolescents are well motivated by all relevant authorities, they will not only avoid getting involved in corrupt practices but will also support the effort of the government to stamp out corrupt practices from the country. To this end, it is recommended that deliberate and comprehensive efforts should be made to acquaint secondary school adolescents with detailed information about countries that have succeeded in stamping out corrupt practices from their societies and how this has made such countries relatively better places to live comfortably. Steps taken by the leadership of such countries in this kind of feat and their commitment to the progress of their countries should also be taught.

The study further reveals that majority of secondary school adolescents agreed on a number of measures that could be taken in order to address the challenge of corrupt practices in Nigeria effectively. This shows that the challenge of corrupt practices in the country is not without possible and effective solution. It is therefore recommended that government and all relevant agencies should be more proactive and sincere in addressing the problem of corrupt practices in the country.

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FACTORS INFLUENCING THE USE OF POINT OF CARE ULTRASOUND (POCUS) ON ADULT PATIENTS BY ACCIDENT AND EMERGENCY DEPARTMENT (A&E) DOCTORS IN TERTIARY CARE HOSPITALS IN COLOMBO DISTRICT, SRI LANKA; A DESCRIPTIVE CROSS-SECTIONAL STUDY

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ABSTRACT

Introduction:*Point of care ultrasound (PoCUS) is an essential component of A&E setting all over the world. It is used for diagnosis and assisting bedside procedures. Usage of PoCUS has been shown to improve quality of patient care. There are no formal studies in Sri Lankan A&E setting to assess level of its usage and the barriers of using it. This study aimed to assess these aspects among ED doctors in three tertiary care hospitals in Colombo district.*

Methodology*:This descriptive study was conducted by self-administered questionnaires distributed among 72 ED doctors working in the above setting. Questionnaire consisted of questions related to sociodemographics, types of PoCUS performed, barriers to PoCUS use etc. Ability to perform PoCUS was assessed by Likert grading from 1 to 5 based on operator's own opinion. Statistical analysis was done using SPSS.*

Results*- All the tertiary care emergency services had access to an ultrasound machine. PoCUS has been used for a wide variety of bedside scans and therapeutic procedures. Majority has been used to detect free fluid in peritoneal cavity (66.6%) and FAST scans (65.3%). Post graduate doctors (PG) were more confident in configuring PoCUS machine for procedures than non PG doctors (82.8% vs 5.4%). Ability to perform PoCUS was associated with post graduate exposure, >1 year of experience using it and doing >300 procedures in last 3 months (p=0.001). Main barriers identified for PoCUS usage were lack of training and lack of quality ultrasound machine.*

Discussion*: Though PoCUS is mainly performed by PG doctors, important scans such as FAST, intra peritoneal free fluid assessment are done by non-PG doctors too. Compared to similar international studies, less number of latter doctors were capable of doing PoCUS in Sri Lanka. Empowering these doctors with PoCUS skills will improve the sustainably of this service in emergency care setup as they work in units for longer duration. A study where candidates' skills are assessed by a third party would have provided more accurate reflection of PoCUS usage.*

Conclusion: *Embracing updated technology and further improvement and availability of PoCUS training among ED doctors will enhance sustainable emergency patient care in Sri Lanka.*

KEYWORDS: PoCUS, Accident and emergency treatment unit, National Hospital of Sri Lanka, Emergency medicine

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1. INTRODUCTION

Ultrasound scan is a widely used cross sectional imaging modality in many facets in clinical practice for both diagnostic and therapeutic purposes. Cost effectiveness, possibility to obtain real time images and higher safety profile due to non-usage of ionising radiation has made it popular and acceptable for both clinicians and patients even for repeated usage. Advancement of technology has made ultrasound scanning an even more accurate imaging modality although it has its unique disadvantage of being operator dependent. However, integration of artificial intelligence (AI) will likely eliminate it for a great extent.

Point of care ultra-sonography (PoCUS) allows assessment of patients parallel to clinical assessment; without requiring them to be physically present in radiology department (Valle et al 2019). POCUS is widely used by doctors in emergency departments who are primarily not trained in radiology (Pouryahya et al 2019). POCUS is a vital skill which directly affects patient's management. Since it is also increasingly used in medico legally important cases, doctors who perform it must be properly trained to ensure they meet minimum standards, competency and safety. The machines should be subjected for periodical quality checks with a medical physicist and fault reporting should be done meticulously. Risk of infection particularly in interventional procedures should be minimised adhering to protocols. Therefore, governance of POCUS is important for high quality patient care (April 2023).

In Sri Lanka, POCUS has been used for patient care in different settings such as emergency departments, intensive care units, surgical theatres and wards for a while. Use of POCUS in emergency departments has been more popular recently due to its integration in the post graduate training curriculum in emergency medicine. Several high-quality training programmes, hands on workshops and skill courses are available accredited by reputed overseas institutes for the training, evaluation, and continuous professional development (CPD). These programmes help to improve core skills such as e-FAST, lung ultrasonography, cardiac sonography and basic therapeutic procedures etc. Fortunately, some of these skills do not require a steep learning curve to achieve a minimum standard of competence which is helpful for doctors who had no previous exposure to sonography training in a resource poor setting (Vanderburg et al 2023).

However, there are many barriers for its usage in developing countries due to lack of infrastructure, lack of awareness, lack of training opportunities, and resistance from non PoCUS users (Smith et al 2023). There are no studies done yet to assess this important aspect in Sri Lanka. In this descriptive, comparative, analytical study, we mainly focused to assess the level of usage of PoCUS in emergency departments by doctors, barriers of its usage and their opinions on overcoming those barriers. Outcomes of this study can be used to improve infrastructure, widen training of PoCUS| among doctors for better patient care to sustain for a long time.

2. METHODOLOGY

Seventy-two doctors including emergency specialists and specialty trainees currently working in emergency treatment units (ETU) and accident / emergency units (A&E) at National Hospital of Sri Lanka (NHSL), Colombo South Teaching Hospital (CSTH) and Sri Jayewardenepura General Hospital (SJGH) were recruited. Due to limited number of doctors working in these units, purposive sampling was used. Data collection was done in between January 2023 to June 2023 using a pretested self-administered questionnaire. It consisted of questions such as number of patients cared per week (<200 or >200), number of PoCUS done in last 3 months (<300 or >300), experience of using PoCUS (<1 year or >1 year) type of PoCUS performed, barriers to use PoCUS and suggestions to overcome such barriers. It also assessed the operator's competency in their own perception on various diagnostic PoCUS such as FAST scans, assessment of pleural effusions/pneumothorax, basic cardiac views/tamponade assessment, intraperitoneal free

fluid assessment-dengue/liver failure, DVT assessment and assessment of volume status using IVC filling. Also, the ability to perform therapeutic PoCUS such as cannulation and nerve blocks were assessed. Likert grading from 1 to 5 was used to subjectively assess the competency according to operator's personal view. Likert grading 1 or 2 or 3 was arbitrarily assigned as 'not confident' by the authors whereas 4 or 5 assigned as 'confident' in doing a procedure. Although there are formal tools such as UCAT (Ultrasound Competency Assessment Tool) to assess PoCUS, these were not used in this research as the responses were self-marked by the candidates (Bell et al 2020).

Ethical clearance for the study was obtained from the Ethical Review Committee of Post Graduate Institute of Medicine, University of Colombo (Reference number: EC 22-121).

3. RESULTS

Out of the 72 study participants, approximately half (n=35, 48.6%) had postgraduate qualification in Emergency medicine as this cohort consists of consultant emergency physicians, senior registrars and registrars (Cohort – A). The other group consisted of grade medical officers (n=37, 51.4%), who did not have a formal postgraduate training in emergency medicine (Cohort – B). Numbers of participants who were enrolled to the study from NHSL ETU, NHSL A&E, CSTH ETU, CSTH A&E and SJGH were 18(25.0%), 17(23.6%), 15(20.8%), 13(18.1%) and 9(12.5%), respectively. The ratio between male and female operators in Cohort A was 16:19, and in Cohort B it was 20:17. All participants agreed that there was a functioning ultrasound scan machine to perform PoCUS in their respective units.

A wide range of PoCUS, both interventional and diagnostic has been performed by all participants although the most commonly performed ones were the abdominal sonography to exclude free fluid in dengue /liver failure (n=48, 66.6%) and focused abdominal sonography for trauma (n=47, 65.3%). Its clear according to table 1, that doctors with post

Table 1. Experience, types of procedures and training

Variable	Doctors with Post graduate qualifications (Cohort – A)	Doctors without Post graduate qualifications (Cohort – B)	Total
Number	35(48.6%)	37(51.4%)	72(100%)
Age (years)	37.7(32-42)	41.4(30-52)	39.7(30-52)
M:F ratio	1:1.19	1.17:1	1:1
Experience of using PoCUS			
<1 year	9(25.7%)	8(21.6%)	17(100%)
>1 year	26(74.3%)	29(78.4%)	55(100%)
Number of PoCUS performed last 3 months			
<300 >300	16(45.7%) 19(54.3%)	34(91.9%) 3(8.1%)	50(100%) 22(100%)
Number of patients cared per week			
<200	22(62.5%)	32(86.5%)	54(100%)
>200	13(37.5%)	5(13.5%)	18(100%)
Types of scans usually performed (diagnostic/therapeutic)			
FAST/EFAST	35(100%)	12(32.4%)	
DVT	20(57.1%)	13(35.1%)	
US abdomen to exclude free fluid (Medical)	34(97.1%)	14(37.8%)	
Gynaecological scan	29(82.8%)	2(5.4%)	
Kidney/ Ureter/ Bladder	22(62.8%)	3(8.1%)	
Testicular dopple	20(57.1%)	2(5.4%)	
Lung	21(60.0%)	2(5.4%)	
Heart (2D Echo/Tamponade)	18(51.4%)	0(0%)	
Fluid status assessment (IVC filling)	35(100%)	6(16.2%)	
Procedural (Nerve blocks, cannulation)	25(71.4%)	4(10.8%)	
Not performed any so far	0(0%)	3(8.1%)	
Prior training of POCUS by;			
Post graduate training programme	35(100%)	N/A	
Fellowship/overse as training	19(54.2%)	0(0%)	
Workshops/ Courses/ Conferences	35(100%)	11(29.7%)	
Online training programmes	26(74.2%)	9(24.3%)	
rained by colleague	29(82.8%)	19(51.3%)	
No formal training (self-taught)	2(5.7%)	11(29.7%)	

N/A – not applicable

graduate exposure have performed more number of PoCUS compared to the opposite cohort (>300 scans during last 3 months 54.3% vs 8.1%). Curiously, inferior vena cava (IVC) for fluid resuscitation has been done by smaller number of Cohort – B doctors (16.2%) being an important core skill. Lung and heart studies were the least performed by both groups. Procedural PoCUS such as ultra sound guided cannulations and nerve blocks were commonly done by Cohort – A compared to B (71.4% vs 10.8%) and 3 participants from the latter group have not done any PoCUS procedure so far.

Cohort A participants had a range of learning experience on PoCUS such as mandatory workshops, conferences, courses and training programmes. Comparatively, Cohort B is clearly underprivileged and most of the training has been acquired by the fellow postgraduate colleagues (n=19, 51.3%). Significant number (n=11, 29.7%) in this group agreed that they have not had any formal training on PoCUS.

Ability to operate ultrasound scan machine and different types of PoCUS were assessed by the Likert grading assigned by the participants. According to table 2, it is again clear that operators with postgraduate background were more confident in setting up the ultrasound machine for the procedure (82.8% vs 5.4%). Also, they were better in getting vascular access for therapeutic procedures like difficult cannulation (85.7% vs 10.8%). However, participants of cohort – B were most competent in performing FAST scans compared to the other studies (54.1%). It was followed by the ability to diagnose peritoneal free fluid (27.0%). However, understandably, the overall confidence in performing PoCUS was significantly better in Cohort – A compared to B (97.1% vs 21.6%). Although Cohort – A participants have not done many lung and heart PoCUS according to table 1, they are still confident in doing those procedures as 94.3% selected Likert 4 or 5.

Minimum ability to perform PoCUS was arbitrarily defined as operators who were confident of adjusting

Table 2. Practice of POCUS

No	Description	Post graduate doctors, (n=35) (Cohort – A)		Other doctors (n=37) (Cohort – B)	
		Confident *	Not confident †	Confident *	Not confident †
1	Confident in adjusting knobs such as gain/depth and choosing correct probe (Minimum ability to perform PoCUS)	29(82.8%)	6(17.2%)	2(5.4%)	35(94.6%)
2	Confident in obtaining vascular access	30(85.7%)	5(14.3%)	4(10.8%)	33(89.2%)
3	Confident in doing FAST/E-FAST	34(97.1%)	1(2.9%)	20(54.1%)	17(45.9%)
4	Confident in diagnosing pericardial effusion	33(94.3%)	2(5.7%)	6(16.2%)	31(83.8%)
5	Can diagnose cardiac tamponade	31(88.6%)	4(11.4%)	6(16.2%)	31(83.8%)
6	Can diagnose pneumothorax	33(94.3%)	2(5.7%)	6(16.2%)	31(83.8%)
7	Can diagnose peritoneal fluid	33(94.3%)	2(5.7%)	10(27.0%)	27(73.0%)
8	Can achieve basic cardiac views	33(94.3%)	2(5.7%)	4(10.8%)	33(89.2%)
9	Can assess response to fluid resuscitation	33(94.3%)	2(5.7%)	7(18.9%)	30(81.1%)
10	All together confidence in performing PoCUS	34(97.1%)	1(2.9%)	8(21.6%)	29(78.4%)

*Likert grading 4 or 5, †Likert grading 1 or 2 or 3

Table 3. Factors affecting performance of PoCUS

No	Factors	p value	Significance
1	Post graduate exposure	0.001	P<0.005
2	>300 PoCUS done last 3 months	0.001	P<0.005
3	>1 year of experience using PoCUS	0.001	P<0.005
4	>200 patients cared per week	0.492	P>0.005

basic knobs in ultrasound machine such as gain/depth and ability in selecting the appropriate ultrasound probe correctly. Therefore, operators who graded themselves either Likert 4 or 5 for this question were considered having minimum ability to perform PoCUS. There were 31(43.1%) doctors who had the ability and 41(56.9%) who did not.

Pearson Chi-square test was used to assess the statistical significance between minimal ability to perform PoCUS against years of experience in using PoCUS, number of patients cared for per week, number of scans done in last 3 months and operator's exposure to postgraduate training of emergency medicine.

Table 4. Barriers and solutions to use PoCUS in hospitals

Description	**Post graduate doctors (Cohort – A)**	**Non post graduate doctors (Cohort – B)**
Barriers in using PoCUS Lack of quality ultrasound scan machines	35(100%)	29(78.3%)
Lack of opportunities to train	31(88.6%)	36(97.3%)
Lack of opportunity to practice PoCUS	29(82.8%)	37(100%)
Lack of trained staff to guide	22(62.8%)	35(94.6%)
Lack of time to use it	27(77.1%)	22(59.4%)
Lack of national guidelines about indications to use it	29(82.8%)	17(45.9%)
Lack of feedback regarding the accuracy of findings	33(94.3%)	15(40.5%)
No idea	12(34.2%)	20(54.1%)
Suggestions to overcome the barriers of using PoCUS		
Increase the number of quality ultrasound machines	31(88.6%)	17(45.9%)
Administrative support	17(48.6%)	12(32.4%)
Develop clear guidelines regarding its use	19(54.3%)	16(43.2%)
Effective training for all ED doctors	27(77.1%)	11(29.7%)
Quality improvement by audits	26(74.3%)	16(43.2%)
No idea	11(31.4%)	9(24.3%)

According to the statistical analysis, only number of patients cared per week did not have a statistically significant association with the minimal ability to perform PoCUS while the remaining 3 factors did.

Regarding the barriers of using PoCUS, both categories agreed with common factors such as lack of access to quality ultrasound machines, lack of opportunity to train/practice it and lack of trained staff as main obstacles. Cohort – A highlighted more on lack of accuracy of findings (94.3% vs 40.5%). They also considered that lack of guidelines on the indications to use it as an important factor (82.8% vs 45.9). With regard to suggestions to overcome barriers, both categories agreed that effective training of all emergency medicine doctors across all categories is essential (45.7 vs 97.3%). Necessity to improve the quality of findings and the necessity of doing regular audits were also highlighted by both parties (74.3% vs 43.2%).

4. DISCUSSION

Studies on use of PoCUS in Sri Lanka are sparse and as far as we are aware, this is the first comparative study to assess a wide range of questions such as the ability in using PoCUS, range of its use, factors affecting its usage, barriers to overcome and improve its availability among ED doctors. According to this study, almost half of the doctor population doing emergency work in 3 major hospitals are consultants or trainee doctors in emergency medicine. Almost all doctors (n=69, 95.8%) have performed PoCUS and nearly 75% have experience in using it for more than 1 year. However, not only the postgraduate doctors are significantly more confident in performing PoCUS (No 10, Table 2), they are also capable of performing a wider range of scans. In addition, more number of scans has also been performed by the same group (Table 1). Doctors who have not got a postgraduate exposure were somewhat good at core skills like performing FAST scan (54.1%) and assessing intra-abdominal free fluid for dengue and liver failure (27.0%). However, therapeutic PoCUS such as getting vascular access and nerve blocks was outnumbered by doctors with postgraduate

qualifications (71.4% vs 10.8%).

The reason for this disparity is lack of proper training opportunities for grade medical officers compared to clear structured training programme their colleagues are enrolled in. The training the medical officers have got is largely based on informal teaching by their postgraduate colleagues and on experience from previous units they had worked in. Therefore, it is important to arrange access to high quality training for all grade medical officers to ensure smooth running and provision of quality care in emergency units. Since 97.3% of non PG doctors agree that they do not get enough opportunity to do PoCUS, arrangements should be made to ensure they get equal opportunity during the learning curve. It is imperative to enforce medical officers with PoCUS skills for sustainability as they remain in these units for a longer period of time compared to postgraduate trainees who come over for shorter periods during training rotations.

Although all units were equipped with ultrasound scan machines, doctors with postgraduate qualifications were apparently not happy to use them. This could be because these machines are not equipped with doppler facility and appropriate probes to perform more specific PoCUS compared to widely performed FAST / abdominal scans. Since such machines and their accessories are expensive, it is not fair to anticipate its wider availability anytime soon due to the current financial constraints of the country. On the other hand, its important at least one newer sophisticated machine made available in high volume centres to ensure provision of better care and training opportunities for ED doctors.

Apart from quantity, quality of the results of PoCUS is also equally important for patient care. Although assessing the accuracy of the findings was beyond the scope of this study, majority of doctors (n=48, 66.7%) have raised concerns on lack of feedback on the accuracy of findings. A number of patients who undergo scans would have it repeated by radiology department by more experienced operators. Doctors who are keen can follow them up to for learning purposes although lack of a picture archiving and communication system (PACS) would make this effort more cumbersome. Since most tertiary centres are manned with consultant emergency physicians, their junior colleagues can always seek help from them to cross check the accuracy of findings (Chen et al 2021).

Conflicts in sonographic findings can potentially risk proper patient management too. Also, it may attract friction between other specialties performing ultra sound scans. Therefore, clear guidelines, which specify the procedures to be followed by emergency doctors should be available. For that to happen, the ability of ED doctors to perform PoCUS beyond a minimum standard should be sustainable. This further reiterates the importance of training a cadre of doctors who are serving such units for longer periods of time. Apart from training programmes that can be organised by professional colleges with the help of both national and international affiliations, in-service training programmes would also help to regularly audit the quality of PoCUS results. For that to happen, a better partnership with the radiology department of these hospital is imperative to ensure increased training opportunities for emergency doctors without compromising training of radiology trainees (Ienghong et al 2022).

A study conducted in an emergency department in Australia to assess diagnostic and procedural utility showed that PoCUS was mainly for diagnostic process (88.2%). Most of the time PoCUS was conducted by Senior Medical Staff Fellows (66.4%) of Australian College of Emergency Medicine (SMS FACEM) (Mosier et al 2019). In our setting, it was mostly used for diagnostic rather than guided procedures. However, this study shows that postgraduate doctors have performed more PoCUS compared to non-postgraduate doctors (54.3% vs 8.1%).

A quasi-experimental study done in Korean Teaching hospital ED identified that the non-availability of equipment, technology, operator's skills, electronic storage capacity as main barriers to PoCUS (Léger et

al 2015). In our setting also main barriers identified were lack of quality ultrasound machines and lack of training. Also, further research would be needed in other districts of Sri Lanka to get a true reflection of PoCUS usage levels and barriers in the country.

Since data was collected by self-administered questionnaire, accuracy of the findings may not be satisfactory. When assessing a complex skill like performing PoCUS, entire dependence on the operator's response may lead to bias. Further research in future where PoCUS skills are observed by an independent third party would give more accurate results. A randomised study would have eliminated bias between two categories to give more accurate results. However, most of the descriptive findings in this study indicated clear-cut differences between the two groups, so the confounding factors may not have affected the ultimate result significantly.

5. CONCLUSION

Tertiary care centres in Sri Lanka have got sufficient level of infrastructure and expertise to perform a wide range of PoCUS largely due to the contribution of trainee doctors and emergency physicians.

To ensure sustainability and better patient care, authors recommend to empower grade medical officers working in emergency departments with PoCUS by providing equal opportunities in training. Empowering major centres with modern equipment as a medium term goal will further improve quality of care and provide superior training opportunities for all ED doctors.

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ENHANCING THERMAL AND DAYLIGHT PERFORMANCE OF HISTORIC BUILDINGS WITH PASSIVE MODIFICATIONS; A TROPICAL CASE STUDY

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ABSTRACT

Historical buildings worldwide hold immense potential for adaptive reuse within the framework of the circular economy, a concept gaining traction in the building construction industry for its role in reducing carbon emissions. Many of these structures boast passive building design strategies, which inherently lower energy demands. Among these, thermal mass and daylight harvesting emerge as pivotal strategies for achieving indoor thermal and visual comfort, respectively. However, with the advent of significant climate change and evolving built environments, the efficacy of these historical passive strategies is subject to debate. This study focuses on a residential building constructed in the 17th century by Dutch settlers in Galle, Sri Lanka, serving as a case study. The research targets improvements in both thermal and visual comfort. Thermal performance analysis was conducted through air temperature measurements, revealing a notable 3-hour time lag and a 2.5°C reduction in peak air temperature during the day. Conversely, nighttime measurements indicated a rise in indoor temperature compared to ambient conditions. Using Design Builder software, the building was modelled to assess its daylighting conditions. Drawing upon thermodynamic principles and daylight harvesting techniques, the study proposes building envelope interventions and ventilation strategies to address nighttime overheating and enhance daylight utilization. The results demonstrate that these modifications can potentially reduce nighttime heat by 2-3°C, while also decreasing the energy requirement for lighting comfort from 51.10 kWh/m² per annum to 44.84 kWh/m² per annum. This research showcases the effectiveness of judiciously implemented interventions in historical buildings, illustrating tangible improvements in both thermal/visual performance and energy efficiency. Leveraging inherent qualities of historical structures and integrating modern design strategies to these buildings can play a vital role in sustainable urban development and energy conservation efforts.

KEYWORDS— Thermal Comfort, Passive Design Strategies, Historic Buildings, Building Preservation

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1. INTRODUCTION

Buildings are responsible for more than 30% of the global final energy use (Berardi, 2017). When it comes to the operational building phase, a significant amount of energy is used to gain thermal and visual comfort (Pathirana et al., 2019). To achieve Paris Agreement targets, the building sector must be fully decarbonized by 2050. Carbon emissions from buildings can be reduced through triple strategies: reducing energy demand, decarbonizing the power supply, and addressing embodied carbon (United Nations Environment Programme, 2021).

According to the previous research, the thermal comfort of the residential buildings of Sri Lanka should be improved (Karunathilake et al., 2018). When it comes to visual comfort, very little research in this regard has been done in the Sri Lankan context. Thermal comfort, visual comfort and energy efficiency in buildings can be improved by using passive building design strategies (Ahsan, 2009). Higher thermal mass and natural ventilation have been identified as long-used passive strategies to achieve thermal comfort (Rajapaksha and Halwatura, 2020), while full use of natural lighting has been identified as a passive strategy to achieve better visual comfort (Zhen et al., 2019).

The vernacular architecture is transferred from generation to generation, and it is an art developed through trial and error. This vernacular architecture is positively responding to the regional climate (Albatici, 2009). Energy experts believe that old architecture's passive building design strategies can reduce energy usage and reduce emissions (Wang et al., 2021). On the other hand, some researchers argue that the passive building design strategies used in old buildings are no longer valid. Those strategies were developed to fit the climatic and other built environmental conditions of those early years (Shen et al., 2020).

This research intends to evaluate the thermal and lighting conditions of the identified colonial building in Sri Lanka, which can be reused for many years by saving its embodied carbon and energy, and then to fix the uncomfortable period by introducing potential passive design strategies to enhance thermal and visual comfort without compromising the historical value of the buildings.

The Galle Fort is recognized as the largest Dutch colonial city that survives outside Europe. It has a blend of European and South Asian Architecture. UNESCO declared the Galle Fort as a world heritage under criteria (iv) in 1988 (UNESCO World Heritage Center, 2022). The statistics show a dramatic functional change in the Galle Fort area due to the booming tourism industry (Jinadasa, 2020). Both internal and external spaces have been changed due to the changing lifestyles, ethnicities, and needs of the residents (Rajapakse and Silva, 2020). The Galle Dutch Fort area was selected for this research on that base.

2. METHODOLOGY

2.1 Pilot Survey to Select a Suitable Residential Building

Thirty residences that belong to the Dutch-era were selected for the pilot study. The original Building plan and sections of those houses were obtained from the Galle Heritage Foundation (GHF) and evaluated to identify the similarities. Current arrangements of the selected houses were studied through field visits and interviews.

Out of the building plans referred to, No. 28, Middle Street house showed a comparatively excessive wall thickness of 3 feet in its outer envelope, which was impressive in terms of indoor thermal behaviour. Mainly based on the available literature on impressive thermal performances among the selected residences in Galle Fort (Rajapaksha et al., 2013) and further based on the practical scenarios such as the owner's willingness to help with the research, No. 28, Middle Street house was selected for this study

A. Front view of the case study residence from the road

B. Main door area and the living room

C. View of the front verandah

D. View of the courtyard

Fig. 1. Photographs of No 28, Midde Street, Galle Fort

Fig. 2. Location of the No 28, Middle Street,Galle Fort

(Jinadasa, 2020; Rajapakse, 2011). Fig. 1 shows some of the photographs of the building and Fig. 2 shows the location of the selected building. No. 28 Middle Street building was built around 1680s as a residential building and still it is used as a residential building. The floor area of the building is 181 m^2.

In the selected residence, the construction materials used were evaluated through GHF databases and were confirmed by site visits. Those data were verified through expert interviews and literature as well.

2.2 Methodology

Indoor and outdoor air temperature was measured in the selected house on March 06th, 07th, 08th of 2022, considering the average high temperature. Three-hour averaged ambient temperature. data for the same dates were taken from M.E.T Department in Sri Lanka. The air temperature measurements were Recorded in the verandah, living room, dining room and courtyard at the upper level (Fig. 3) in the selected building with Hobo loggers, to identify the

thermal behaviour in each space separately.

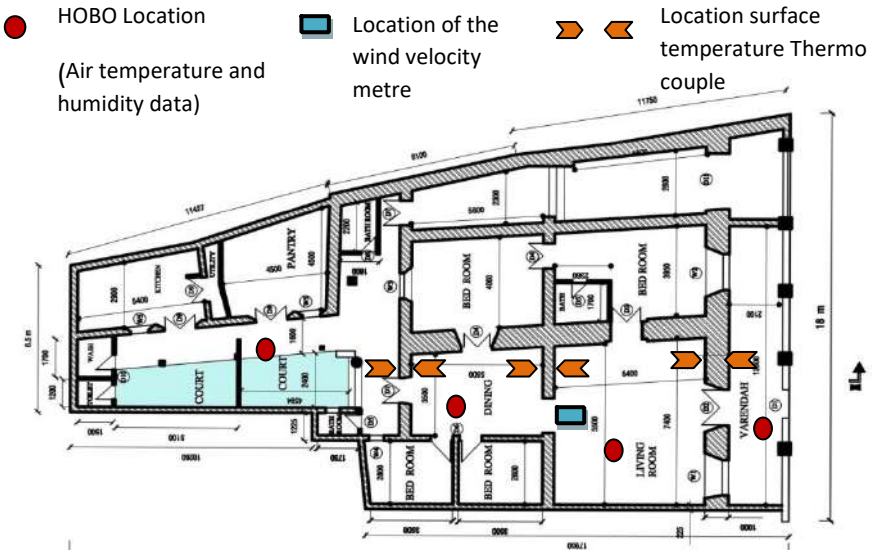

Fig. 3. Locations of the equipment for data collection

Table : 1: Changes introduced and purposes of the changes

Changes Introduced to the Model	**Purpose of the Change**
Create an upper opening near the ridge level of the roof (facing wind shadow direction)	To remove the indoor heated air out, by stack effect
Low-level openings introduced from front and courtyard side facades	To pull cool air from outside to fill the vacuum created by the stack effect (with top opening) at night and promote wind circulation.
Make a schedule for openings - Lower and upper openings are fully opened during evening and night - About 95% of the external envelop is closed during daytime - Introduced upper openings are operatable and made with 90% transparent material	To promote cross and stack ventilation at night To avoid entering wind inside which carries heated Air outside at daytime For daylight harvesting and improving lighting condition

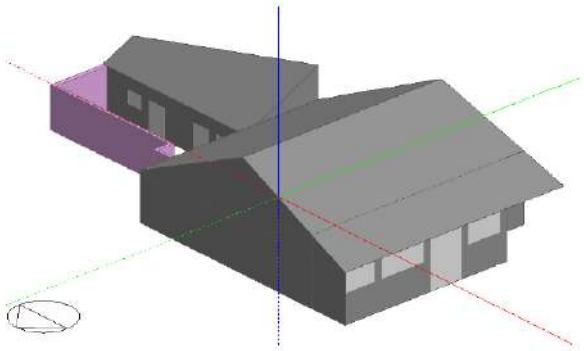

Fig 4: Design Builder model for the selected case study house

Using Design Builder (DB) version 6, the case study house was modelled and validated to make similar conditions and further thermal and lighting performance evaluations of the building were conducted (Fig. 4).

Potential building modifications were analyzed by applying known principles of building physics such as thermodynamics and air-fluid dynamics (Table 01).

The optimum potential modifications to the building envelope were introduced to enhance the thermal and

lighting performance of the building. The validated Design Builder model for the actual building was modified according to the newly suggested features.

Then the model was analyzed for indoor air temperature, fluid dynamics, daylighting, and energy consumption.

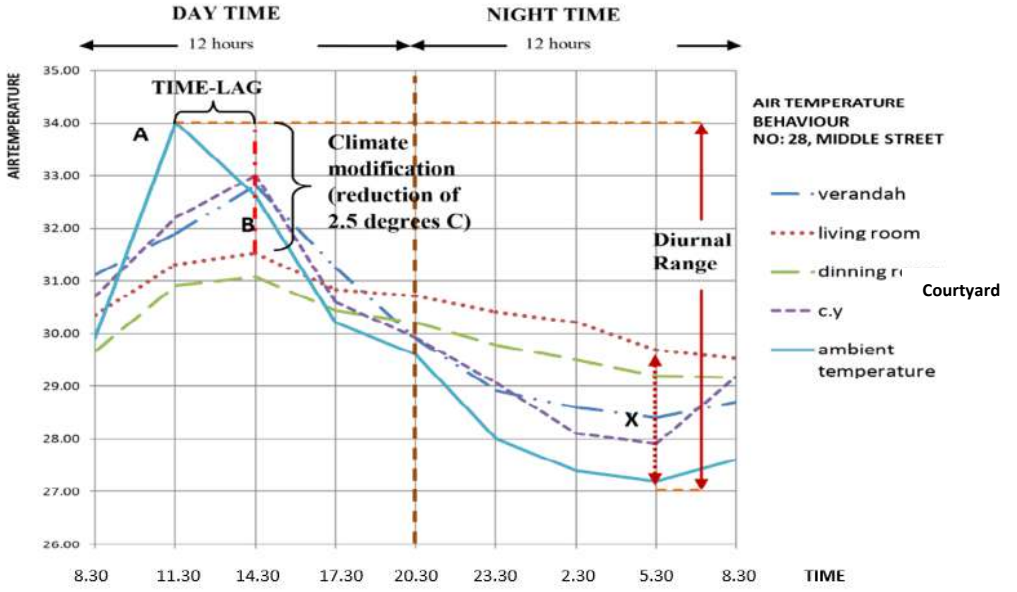

Fig. 5. Air temperature comparison of the building

3. RESULTS AND ANALYSIS

3.1 Thermal Performance

The air temperatures of the selected case study building are shown in Fig 5. According to the temperature graphs, the ambient air temperature reaches its peak at 11.30 a.m., and the indoor air temperature reaches peaks after some hours from the ambient peak time, at 2.30 p.m. In other words, the indoor air temperature reaches its maximum 3 hours after the ambient reaches its maximum; this delay is called 'time lag'. Further, it shows an apparent reduction of 2.5 ^{0}C from the outside temperature. 'X' in the graph shows the temperature difference between nighttime ambient temperature and indoor temperature.

When it comes to nighttime, the indoor temperature is higher than the ambient temperature. This phenomenon is because the walls are very thick, and they absorb much heat making the indoors cool in the daytime and release much heat at night. The advantage of cool night ventilation is not integrated to reduce indoor air temperature during the night. This is mainly because buildings are not designed for nocturnal ventilation, and thus internal thermal mass does not get sufficiently cooled.

In addition, there are no openings in the building section to remove hot air at night. Due to this stagnation, the indoor temperature at night is higher than the outdoor ambient temperature.

Further, the courtyard temperature is 1.6 ^{0}C higher than the living room temperature in the daytime. The courtyard has become another overheated element, and there is a potential for heat gain indoors from the courtyard. Although the courtyard becomes cool at nighttime, there is no opportunity provided by the building design to take that cool air inside, as all the openings are closed at night. Regarding the above scenario, attention was paid to introducing night ventilation to remove this stagnated heat within the house (Givoni, 2011).

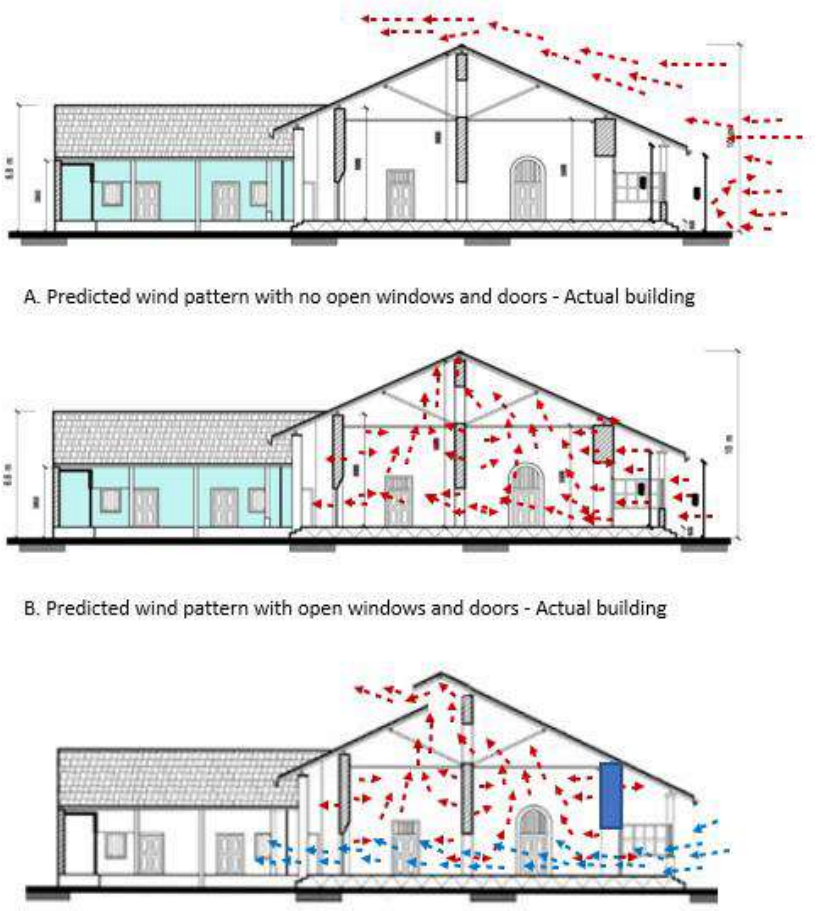

Fig. 6. Predicted wind patterns according to the air-fluid dynamic principles (stack effect and stack-induced ventilation)

The living room and the dining room have low-temperature values compared to the other two locations in the daytime. In the nighttime, these two locations show higher temperature values. This is because living and dining rooms are directly connected to the thicker walls and when it comes to the volume air, living and dining rooms have a higher volume than the verandah area.

For this, priority was given to passive strategies, and it was decided to promote ventilation within the building at night by considering established theories on airflow dynamics and thermodynamics (Fig.6). Scheduled openings were introduced at the bottom of the building to facilitate cool air inflow. Scheduled openings were introduced at the top of the building to facilitate hot air outflow (Toe and Kubota, 2015).

The calibrated Design Builder model was modified with an opening at the top and bottom levels (Fig 7). Further, Table 1 shows the changes introduced to the model and the purpose of the introduced changes. As shown in Fig 8, after promoting night ventilation, the simulation result shows a significant reduction in indoor air temperature from the air temperature in the actual situation during the night and even daytime.

A fluid dynamic analysis was done to identify the airflow pattern of the building, and it was similar to the prediction done at the beginning (Fig 9 and Fig 10). Then the original building was simulated with an HVAC system to get the same thermal comfort, and it gives 36.72 kWh/m^2 per annuum as required cooling energy.

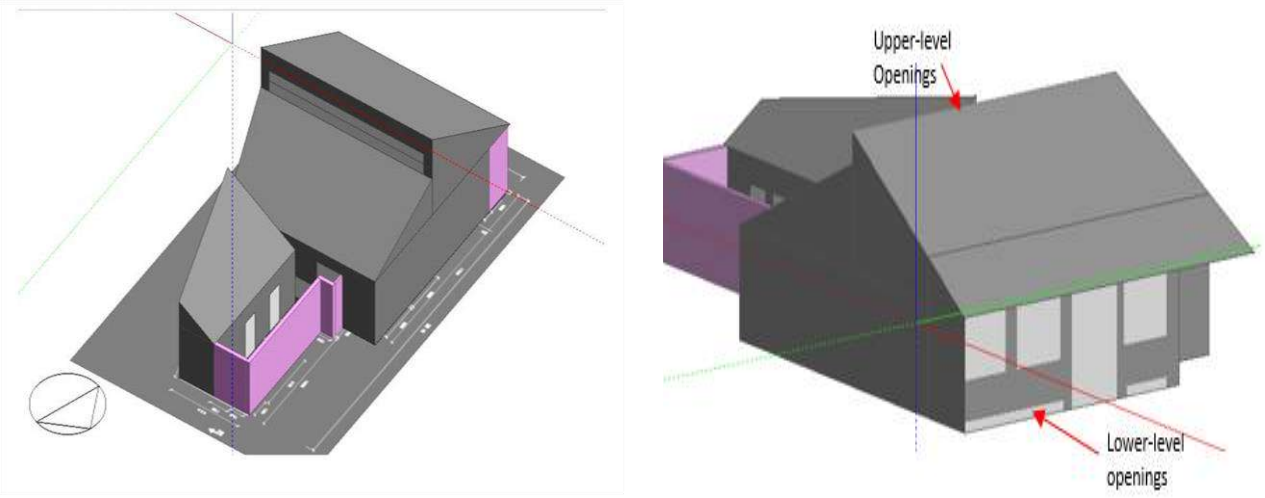

Fig. 7. DesignBuilder model of the modified building

3.2 Lighting Condition

Design Builder software model was analyzed for the daylighting condition of the actual building model (Fig 11 A). According to the model results from the illuminance level of the building, some parts of the building do not get lighting at all. It was very similar to the actual situation in the house.

Then the modified building was simulated for daylighting (Fig 11 B). According to the illuminance level, the lighting condition was improved; still, it needs further modifications. Hence it is planned to study further the modifications that can be adopted to enhance the lighting condition of the building. When it comes to energy consumption, the actual building needs 51.10 kWh/m^2 per annum, while the modified

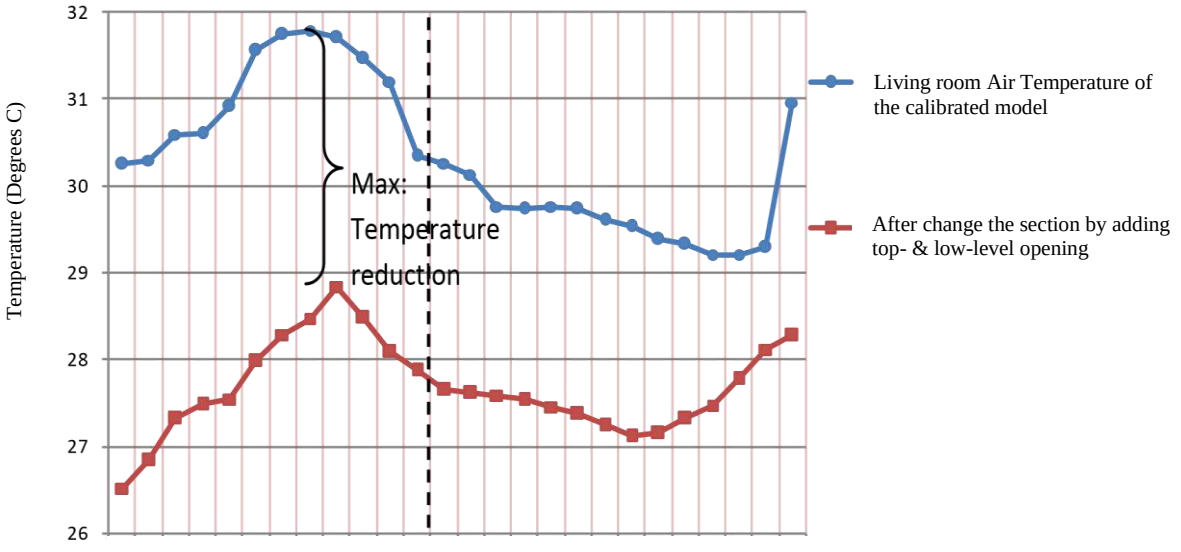

Fig. 8. Air temperature comparison of the actual building and the modified building

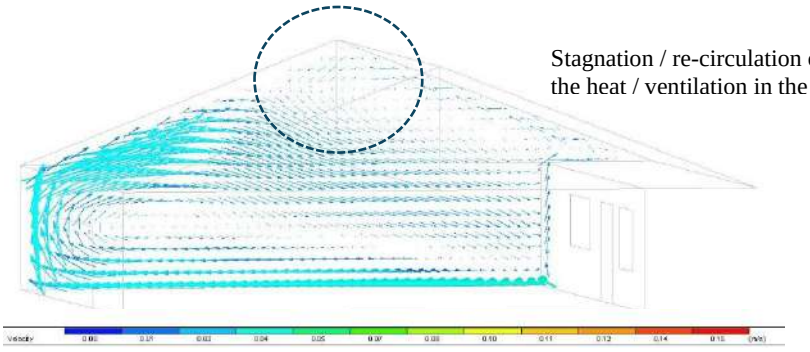

Fig. 9. Air flow pattern of the existing

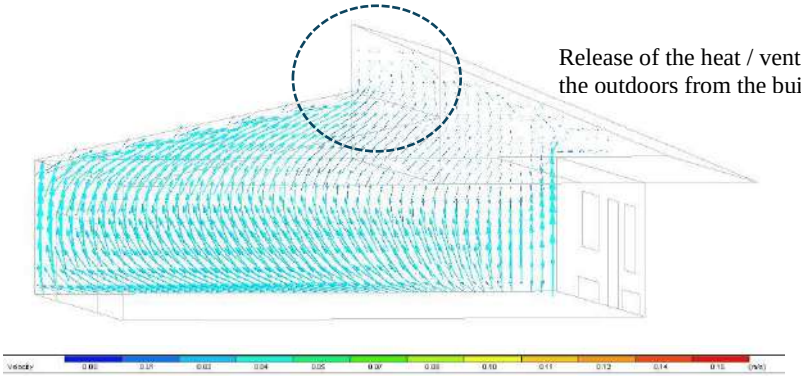

Fig. 10. Air flow pattern after modifying the building with upper and

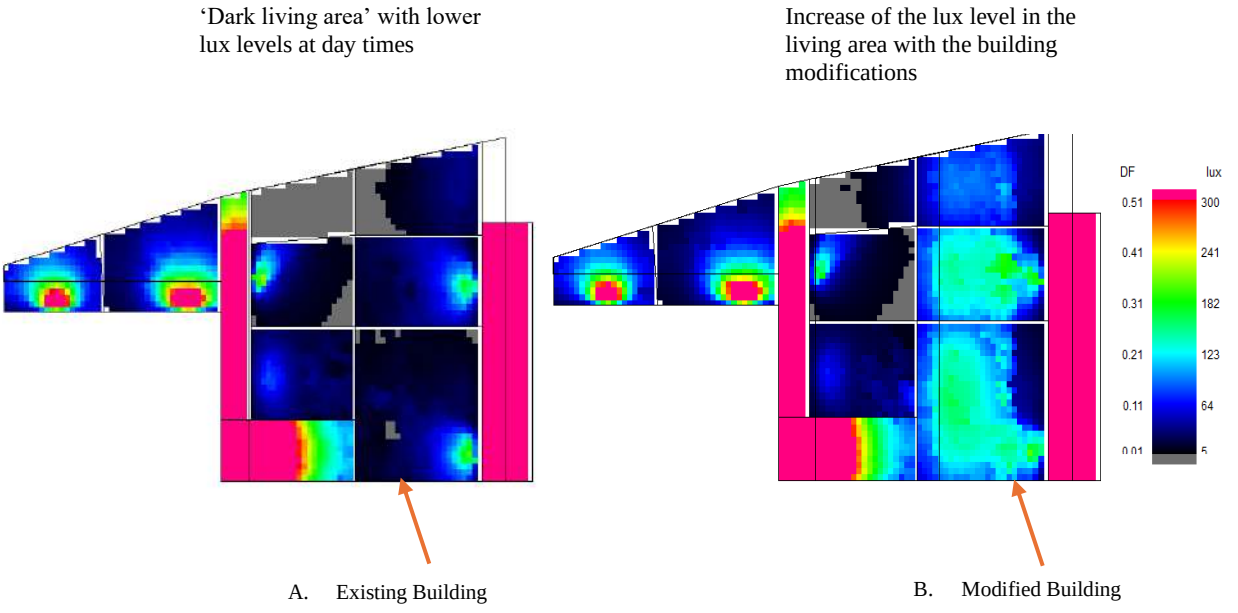

Fig 11. Daylight Conditions

building needs 44.84 kWh/m^2 per annum. In a previous study done by Rabani et al. 2021, the minimum energy requirement for achieving visual comfort was found as 55 kWh/m^2 per annum.

4. DISCUSSION

Vernacular Architecture is renowned for its passive design principles, yet the applicability of these concepts in modern contexts is a subject of debate. The changing climate, evolving built environments, and shifting building standards raise questions about the effectiveness of traditional passive design in present-day scenarios. This study aims to evaluate the thermal and visual comfort of old buildings, proposing design modifications for the building envelope while preserving their historical significance.

The architecture of the Galle Fort Dutch-era buildings blend elements of Sri Lankan vernacular architecture with authentic Dutch design (Rajapakse, 2011). This unique combination results in structures that incorporate features from both hot arid and warm, humid climate architectures. Notably, these buildings exhibit characteristics such as high thermal mass and narrow high courtyards typical of hot arid climates, alongside large openings and open courtyards aligned with the main wind axis for ventilation, common in warm, humid climates.

In the case study, the original building exhibited a 3-hour time lag and a 2.5°C reduction in indoor temperature compared to ambient conditions during the daytime. However, nighttime temperatures were higher indoors due to the building's thick walls and lack of proper night ventilation. To address these issues, scheduled openings were introduced at the base of the building to facilitate the entry of cool air along the wind flow direction. Additionally, upper-level openings were implemented to allow for the escape of hot air, aiding in passive ventilation.

Previous research has highlighted the benefits of using high thermal mass and natural ventilation (Pathirana et al., 2017; Rajapaksha, 2016). Thick earth walls, in particular, have been identified as effective thermal mass materials (Tharanga et al., 2011). Natural ventilation not only enhances indoor air quality but also contributes to passive cooling strategies (Pathirana et al., 2017).

To mitigate the stack effect, which leads to heated air rising and accumulating, openings were strategically positioned at upper levels to facilitate the removal of hot air. Lower-level openings were designed to introduce cool ventilation, creating a circulation pattern within the building. These strategies align with previous research on incorporating secondary wall systems with low-energy mechanical ventilation to further enhance passive cooling (Rajapaksha, 2016; Rajapaksha et al., 2022).

In the current scenario, building occupants resort to artificial lighting during the daytime for visual comfort, highlighting the need to explore the impact of proposed modifications on both thermal and visual comfort. Balancing these two factors can be challenging, as they often conflict (Rabani et al., 2021). However, the introduced interventions aimed to enhance visual comfort while reducing energy consumption for lighting has resulted in a decrease from 51.10 kWh/m² per annum to 44.84 kWh/m² per annum.

5. CONCLUSION AND RECOMMENDATIONS

In conclusion, the effective utilization of high thermal mass for passive climate modification in warm, humid climates necessitates a careful balance of ventilation strategies. While avoiding daytime ventilation, except through shaded and cooled areas, is advised to prevent the intrusion of polluted urban air and to ensure privacy, promoting night ventilation is crucial for leveraging the stack effect and maximizing the benefits of thermal mass. Independent use of thermal mass without adequate ventilation does not yield the desired results in these climates.

Moreover, the presence of courtyards in these buildings, often intended to enhance ventilation

through an air funnel effect, has inadvertently led to inefficient heat transfer and diminished the efficacy of thermal mass. Therefore, a reevaluation of the courtyard design is recommended to prevent the air funnel effect and to optimize thermal comfort indoors.

Additionally, to reduce daytime energy usage for lighting and to enhance overall energy efficiency, the implementation of daylight harvesting systems is strongly encouraged in these buildings. Conducting thorough assessments of actual lighting conditions in vernacular architectural buildings is essential to identify existing issues and opportunities for improvement.

Looking forward, further research should focus on identifying and developing passive strategies that not only promote thermal comfort but also optimize daylight utilization. This includes investigating innovative building technologies and design approaches tailored to warm, humid climates. By implementing these recommendations and advancing research in passive design strategies, architects and engineers can contribute significantly to sustainable building practices that prioritize energy efficiency, thermal comfort, and indoor environmental quality in these challenging climates.

6. ACKNOWLEDGEMENT

Our sincere gratitude goes to the Galle Heritage Foundation and Residents of No 28, Middle Street, Galle Fort.

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ADOPTING ISO 9001:2015 & ISO 21001:2018 EOMS TO THE SRI LANKAN HIGHER EDUCATIONAL INSTITUTIONS: A REVIEW OF LITERATURE

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ABSTRACT

Higher education is the critical economic sector that is eventually followed by all other major service sectors in an economy such as financial services, healthcare, telecommunication, aviation, transportation etc. Today, higher educational institutions all over the world operate in a fast-dynamic environment with high competition for reputation, talent acquisition, and student attraction. Following the basis of that high competition that is leading to a significant focus on quality. It is not easy to define the quality in terms of higher education since due to the complexity in relationships of higher education to students and the different roles played by a student in the higher education process. Addressing the issue, International Organization for Standards (ISO) has recently published a new quality framework for higher educational institutions; ISO 21001:2018 EOMS and most of the institutions adopted ISO 9001 standard series until the publication of the new ISO standard for higher education. This study employs an evidence-based approach and systematically evaluates the existing literature on ISO QMS implementation in higher education institutions in different countries with the intention of elaborating on the necessity of adopting it in the Sri Lankan context. Further, it attempts to summarize the key benefits, challenges, and critical success factors of ISO implementation considering Sri Lanka. According to the findings, the key benefits of ISO adoption by higher education institutions are cost reduction, consistent customer satisfaction, risk management, international recognition, adopting rapid changes, attracting grants/ funds, and strengthening international linkages and relationships. In addition, the challenges and critical success factors which were extracted from the literature are also stated for easy implication. Thus, the study highly recommends implementing ISO-standardized quality management systems in all higher education institutions in Sri Lanka to mitigate the serious limitations while achieving international recognition for all educational programmes to finally generate a quality workforce for the economy.

KEYWORDS: *Quality, ISO 9001:2015, ISO 21001:2018, Higher Education, Sri Lanka*

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1. INTRODUCTION

The higher education sector comprises educational institutions that provide systematic learning opportunities for individuals to acquire vast knowledge in different fields (Sitopu *et al.*, 2024). Higher education institutions (HEIs) serve as a catalyst for nurturing individuals' capabilities to leading towards pioneering transformations in different sectors in the modern society. In response to evolving needs in higher education, institutions are compelled to enhance their efficiency by being quality oriented (Shiong Pong, 2023; Tubagus and Fathurohman, 2023; Sitopu *et al.*, 2024). HEIs as pioneers of social transformation, they are capable of fostering creativity and developing innovative, high-quality and responsive leadership approaches to contribute to the global developments and local challenges while having foresight to identify future trends.

Quality consists of several general principles that are being upgraded with time. The prominent quality principles at all times include customer satisfaction, continuous development, teamwork practice, decision-making based on facts and data, empowerment and problem-solving (Evans and Dean, 2000). In addition, the literature provides quality dimensions elaborating on the higher education sector. In the late 90s, Garvin, 1987 provided the eight quality dimensions given in Table 01, which elaborate on how they can be applied in higher education.

Developing and following a proper quality management system is one of the critical responsibilities of all HEIs (Hernandez, 2010). Even though HEIs are liable to maintain a proper quality assurance mechanism, typically there are no standard specifications for the structure and contents of such a system. Therefore, HEIs have the freedom to develop their own quality assurance system and procedures to align with the institutional strategic and operational objectives. Further, that autonomy permits HEIs to obtain external support to audit the quality assurance system and to choose the internal quality assurance systems as they intend (Kettunen, 2012). Accordingly, the non-availability of a standard quality assurance mechanism that could be applied generally across all HEIs has created several issues in the field of higher education worldwide. Such issues caused a huge quality gap among HEIs operating under the same conditions, unnecessary competition among the students when choosing some HEIs, not having proper recognition for some programmes offered by several HEIs and the contents of the programmes are not being updated to fit with the industrial requirements can be highlighted (Kistan, 1999).

Table 1 : Eight quality dimensions and their relevancy in higher education

Quality Dimension	Applications in Higher Education
Performance	Primary knowledge & required skills for graduates
Features	Supplementary knowledge and skills (Secondary)
Reliability	The accuracy and update of the knowledge and skills provided.
Conformance	The extent to which an institution meets established standards, plans, and promises.
Durability	Depth of learning
Serviceability	How well an institution handles the complaints of the customers.
Aesthetics	The attractiveness of programmes and teaching methods.
Perceived quality	Overall satisfaction

In the way of finding solutions for the above issues and mismatches in higher education, HEIs in many countries in the world have taken action to adopt ISO standards for all possible levels, procedures, and stages of their educational programmes (Singh and Sareen, 2006). Before 2018, ISO Standardization had not covered the educational sector or established a separate standard for it. Therefore, educational institutions have adopted ISO 9001 since its founding version of 1987

and followed the subsequent versions in 1994, 2000, 2008 & 2015. Since ISO 9001 is directly related to the manufacturing sector, it might cause some ambiguity in the practices in the educational sector. Accordingly, ISO published a new quality standard for the education sector, ISO 21001:2018 EQMS which specifies requirements for a management system for educational organizations (Kovalenko *et al.*, 2020). The Sri Lankan higher education system is also facing the same issues mentioned above due to the non-availability of a general quality assurance mechanism which assures the overall quality of the different types of processes adopted and services rendered by HEIs. Even though a few national and private universities follow standard quality control systems under the supervision of the University Grants Commission, many HEIs in Sri Lanka do not follow sophisticated quality control systems aligned with international standards.

A research gap exists as there is limited attention towards adopting internationally accepted quality frameworks in Sri Lankan higher educational institutions. This research seeks to bridge this gap by conducting research on adopting ISO quality standards in HEIs employing a systematic literature review since most international universities have already reaped benefits by adopting ISO standards. Accordingly, this study aims to identify the prevailing conditions of adopting ISO 9001 and ISO 21001:2018 EOMS into HEIs in terms of international viewpoint, benefits and challenges of adopting ISO 9001 and ISO 21001:2018 EOMS into the HEIs and Critical Success Factors (CSFs) of adopting ISO 9001 and ISO 21001:2018 EOMS into the HEIs. This will enable us to provide a comprehensive overview of the existing research landscape while shedding light on the directions towards adopting ISO in HEIs. By synthesizing existing knowledge, this paper will contribute a holistic understanding of the aspects of ISO adoption into HEIs, paving the way for future research directions and offering practical implications for Sri Lankan HEIs striving to enhance their quality practices.

This research fills the research gaps by identifying and analysing existing research works on ISO 9001 and ISO 21001:2018 EOMS adoption into the HEIs, to provide a holistic understanding of the key areas to be considered for implementation or further research within the Sri Lankan context. The research questions (RQs) are.

RQ 1. What is the current situation of adopting ISO 9001:2015 and ISO 21001:2018 EOMS quality standards into the HEIs in terms of global viewpoint?

RQ2. What are the benefits of adopting ISO 9001:2015 and ISO 21001:2018 EOMS quality standards into the HEIs?

RQ3. What are the CSFs of adopting ISO 9001:2015 and ISO 21001:2018 EOMS quality standards into the HEIs?

RQ4. What is the possibility of adopting ISO 9001:2015 and ISO 21001:2018 EOMS quality standards into the HEIs?

Further, this comprehensive study will foster a greater understanding of adopting ISO 9001:2015 and ISO 21001:2018 EOMS quality standards in Sri Lankan HEIs, and it will contribute to the researchers, practitioners and policymakers interested in this domain.

2. METHODOLOGY

The primary objective of this study is to investigate the suitability of adopting ISO quality standards (ISO 9001:2015 & ISO 21001:2018 EOMS) in Sri Lankan HEIs to enhance their overall quality aligned with international standards. It would provide reasonable solutions for most of the severe issues in the Sri Lankan higher education system. The evidence-based approach was followed to analyze the existing literature. Therefore, the research approach is analytical and explanatory in nature based on the existing literature. Since it was hard to find literature which addresses the ISO quality standards implications in Sri Lanka, literature relating to the implication of ISO standards in HEIs in other countries was mainly considered.

In this study, the Systematic Literature Review (SLR) approach which was described by Tranfield, Denyer and Smart, 2003 was used to implement a comprehensive assessment of existing literature in the study field. The articles were selected adhering to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines, as suggested for

SLRs (Page *et al.*, 2021). Further, the PRISMA approach is well recognized in different research fields including business and management as a standardized method for conducting SLRs (Zahari and Kaliannan, 2022; Aslam and Jawaid, 2023; Olawade *et al.*, 2023). The PRISMA framework provides a structured approach for conducting systematic reviews (Liberati *et al.*, 2009) while it was selected due to its widespread acceptance by many researchers and the possibility of straightforward implementation (Moher *et al.*, 2009). The article selection process of this study followed by the PRISMA guidelines is shown in Figure 01.

In the first stage of the study, the identification of relevant articles was done by searching predetermined terms in selected prominent databases; Emerald, Science Direct, Springer, JSTORE & IEEE. The time span considered for article selection was from 1987 to 2023, since the ISO 9001 standard was published in the year 1987. The search terms were carefully determined and included in the above databases utilizing the "AND" and "OR" Boolean operations to ensure the inclusion of all relevant scholars' works. Finally, the dataset retrieval was carried out from 1987 to 2023 by inserting the following search terms (("higher education institutions" OR "HEIs" OR "universities") AND ("ISO 9001" OR "ISO 21001")) within the title, abstract, and keywords of the existing scholarly studies. A total of 602 publications resulted from the initial search within selected databases. Then the various document types, such as books chapters, conference reviews, editorials, conference papers and repeated articles were excluded. Finally, 321 articles were considered for screening.

Then the remaining 321 publications were evaluated for eligibility following a meticulous manual review. The title and abstracts of each publication were carefully screened to assess their relevancy to the implication ISO 9001 & ISO 21001:2018 EOMS within higher education institutions. A total of 253 publications were excluded due to their focus on other ISO standards, general aspects of the implementation of ISO 9001 and or implementation of ISO 9001 in other industries instead of focusing specifically on HEIs. Subsequently, only 68 articles were selected to be considered for reviewing systematically.

3. RESULTS AND DISCUSSION

Higher Education System in Sri Lanka

The University Grants Commission of Sri Lanka (UGCSL) is the apex body of the university system in Sri Lanka, which was established on 22nd December 1978 under the Universities Act No. 16 of 1978. The functions of the UGCSL are planning and coordinating university education, allocation of funds to Higher Educational Institutions (HEIs), maintenance of academic standards, regulation of the administration of HEIs and regulation of admission of students to HEIs (https://www.ugc.ac.lk/). As per the UGCSL, the updated details regarding the composition of the Sri Lankan higher education system have been summarized in the table 02.

According to the figures in table 02, nearly 76 HEIs are operating in Sri Lanka under the direct and indirect supervision of UGCSL. Therefore, it can be concluded that the Sri Lankan higher education system mainly consists of the above institutions. Currently, many foreign universities offer degrees in Sri Lanka by establishing their branches or in association with private universities. In addition, there are some major professional institutions which offer internationally accepted qualifications which have equal recognition as undergraduate and postgraduate programmes. Even though such foreign universities and professional institutions also significantly contribute to higher education in Sri Lanka, their quality management systems were not considered for this study since they are following separate frameworks provided by international and foreign entities.

ISO 9001 QMS and higher education

Favourable and unfavourable effects of the ISO 9001 standard depend on specific contextual factors, and identifying those factors would help to improve its practical implications by enhancing organizational efficiency and mitigating the risk of misconduct (Boiral, 2011). However, ISO certification should consider as a learning process involving its own drawbacks and benefits and sometimes surprises,

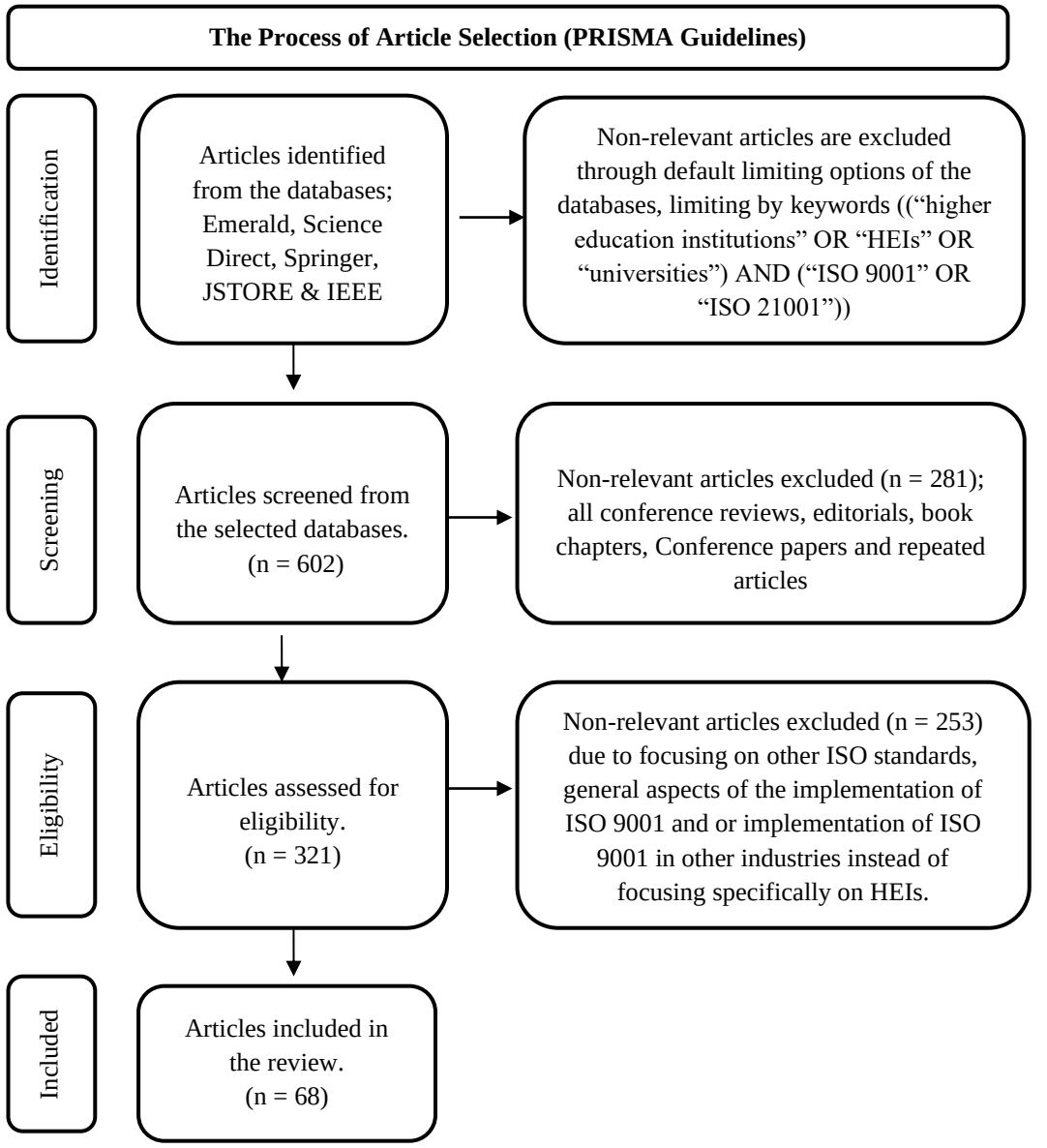

Figure 01: PRISMA Statement (Figure courtesy of Moher et al., 2009)

instead of being taken as a specific goal of just accreditation of the standard (Moturi and Mbithi, 2015). Further to achieve the best outcomes of ISO 9001 implementation, continuous evaluation of data relating to processes, system performance and feedback received from customers must be evaluated and discussed conducting regular management review meetings in order to identify the potential growth opportunities and take corrective and preventive actions (Wahid, 2012).

Even though ISO 9001 is originally focused on industrial background, many service organizations also have adopted it. According to the ISO report (2009), 40 per cent of all ISO 9001 certificates are accounted for service organizations in the year 2008. In particular, the growing interest of higher education institutions to

adopt ISO 9001 has also been observed by some authors since early 2000 (Thonhauser and Passmore, 2006). The main reasons for the adoption of ISO 9001 by many HEIs that could be found from the literature are high competition among educational institutions to attract and retain more students, pressure from governing bodies requesting HEIs to implement continuous processes to promote and improve the quality of education and to make the efficient use of resources to ensure the accountability towards stakeholders and the funding bodies (Gamboa and Melao, 2012).

Table 2: The composition of the Sri Lankan HEIs

Institutional Type	No of Institutions
Public Universities	17
Public Campuses	2
Public Higher Educational Institutions	19
Other Government Universities which are established by Acts of Parliament of Sri Lanka	06
Degrees of Institutes Recognized under Section 25 A of the Universities Act No. 16 of 1978	06
Degree awarding status granted by the Ministry of Education (Specified authority being the Secretary, Ministry of Education)	23
Professional Qualifications Recognized as Entry Qualifications for Postgraduate Degrees.	02
Programmes offered by universities established under Separate Parliament Acts.	01
Total	**76**

At the initial stage, some authors (Peters, 1999; Labaree, 2000) questioned the relevancy of ISO 9001 to higher education. Others (Moreland and Clark, 1998; Sohail, Rajadurai and Rahman, 2003; Stimson, 2003; Bae, 2007; Costa *et al.*, 2009) revealed the suitability and positive impacts of implementing the early versions of ISO 9001:1994 & ISO 9001:2000 in higher education. In addition, many authors examined the outcomes of implementing the latest versions of ISO 9001:2008 and ISO 9001:2015 in higher education.

The ISO 21001:2018 EOMS and higher education

In the year 2018, ISO published ISO 21001:2018 EOMS a new standard to fulfil the requirements of a specific Quality Management System for educational systems. This standard facilitates educational institutions to achieve continuous improvement by implementing a standardized management system. Although the content of the new standard ISO 21001:2018 incorporates all key concepts of ISO 9001, ISO suggests, educational institutions should permanently discontinue ISO 9001 and transfer to the certification of ISO 21001:2018 EOMS to avoid the inconclusiveness of some areas in ISO 9001 (ISO, 2019).

The educational community might take a considerable period to fully acknowledge and recognize the new standard; ISO 21001:2018. One of the main goals of ISO certification is to boost the corporate profile in marketing strategies. Therefore, more success stories are required to get the attention of educational institutions to adopt ISO 21001:2018 as it is not more popular than ISO 9001 (Wibisono, 2018). Similar to other ISO standards, ISO 21001:2018 is also based on the Plan-Do-Check-Act principle (PDCA principle). It helps organizations to evaluate all the areas of standardization including the focus on social responsibilities and other related aspects. Implenatiation of ISO 21001:2018 generates endless advantages towards the educational sector including better alignmentment of the standard requirements and tasks with the organizational internal policies (Kovalenko et al., 2020).

Although literature that elaborates on the implication of the early versions of ISO 9001 such as ISO 9001:1994 and ISO 9001:2000 in HEIs across the globe is limited, there is sufficient literature with evidence for many

successful cases of implementing the later versions of ISO quality management system standards such as ISO 9001:2008 and ISO 9001:2015 in higher education. In addition, a few studies provide successful cases of implementing the newest version of the ISO quality standard for education, ISO 21001:2018. Accordingly, the benefits and successful cases of the three main ISO quality management systems (ISO 9001:2008, ISO 9001:2015 and ISO 21001:2018) on higher education observed from the literature are presented in the next two sections.

The common benefits of ISO standards; Incorporated into HEIs

In the early 1990s, many organizations started to adopt and implement ISO quality standards, spreading over both government and international organizations (Elgobbi, 2014). According to Brown, 2013, many business entities have initially attempted to obtain ISO certifications to get the government's tenders and enter certain markets. Some researchers revealed that the need of many organizations for ISO certification is based on combined internal and external motives (Tsiotras and Gotzamani, 1996; Beattie, 1999; Yahya and Goh, 2001; Khan, 2003; Blessner, Mazzuchi and Sarkani, 2013) According to the studies conducted by Zaramdini (2007) & (Fotopoulos, Psomas and Vouzas, 2010), ISO 9001 certification would help business organizations to improve their internal functions and performance ensuring standardized quality systems for both manufacturing and service processes.

Other studies conducted in different periods (Arndt and Kustin, 1997; Sampaio, Saraiva and Guimarães Rodrigues, 2009; and Blessner, Mazzuchi and Sarkani, 2013 have revealed that the implementation and application of ISO practices adhering to its general requirements enables the business organization to supply their products and services ensuring the consistent customer satisfaction. Further, the same studies elaborated that some entities have accredited ISO 9001 certification as they strongly believe that the failure to accomplish the requirements of ISO would generate unfavourable impacts on their success and growth. In addition, ISO certification provides an internationally accepted third-party guarantee for their main business and management processes.

The effectiveness of implementing ISO 9001 can be measured by evaluating the levels that the organization has achieved the standard's objectives namely, focusing on customer satisfaction, continuous improvement, and the prevention of non-conformities. Therefore, the effectiveness of ISO 9001 has a direct and vital impact on the operational performance and product quality of the certified entities (Psomas, Pantouvakis and Kafetzopoulos, 2013) The implementation of ISO standards leads to creating favourable impacts on the work culture and routine task management (Muslim and Suradi, 2012).

The specified benefits of ISO standards towards HEIs

According to several studies that have been carried out in Malaysian universities, the right implementation of ISO 9001 standards within the HEIs at the right time leads to significant favourable changes resulting due to the incorporation of well-defined management processes and proper risk management strategies in the process of standardization. Further, the incorporation of ISO 9001 enables Malaysian universities to face challenges and opportunities arising due to technological advancements more confidently. In addition, the development of quality management systems for HEIs aligns with the requirements of ISO standards and helps them to successfully survive in the competitive markets and to be updated in terms of information, creativity, innovation and quality (Othman, Mokhtar and Asaad, 2017).

Andiva & Simatwa (2018) revealed that the preparation of course outlines and timetables adhering to ISO 9001:2008 quality management systems ensure good coordination and considerable cost reduction with maximum customer satisfaction. Further, their study has confirmed that 80% of outcomes with guaranteed service quality can be achieved by utilizing only 20% of resources as a result of adhering to the ISO 9001 quality management system. The findings of the same study revealed another set of massive benefits for HEIs. The accreditation of ISO 9001: 2008 quality management system in universities contributes to attracting grants and funds, esteemed internship

opportunities and strengthening local and international linkages and partnerships with the professional demands. Good partnerships and linkages can be considered as the pillars of HEIs that sustain their development and vibrancy. Thus this recent study emphasizes that the ISO quality management system was a significant determinant of service quality in universities.

The findings of Moturi and Mbithi (2015), a study conducted regarding the implementation of ISO 9001: 2008 QMS at the University of Nairobi present that significant favourable changes have been established due to the institutionalization of ISO quality management systems into the university processes, working environment, record and documentation management, infrastructure and facilities, customer satisfaction, library system and the application of ICT for performance improvement. In addition, the same kind of benefits of implementing ISO 9001:2008 & ISO 9001:2015 QMS in HEIs mentioned above has been reported by many scholars based on their studies conducted across different regions in the world (Supradith, 2001; Bae, 2007; Vusa *et al.*, 2016; Diaz and Mediano, 2018; Balahadia, Dalugdog and Cabiente, 2022; Amalia, Susanti and Asbari, 2023).

Even though the least literature is available regarding the implementation of ISO 21001:2018 EOMS, Gilbert, (2020) explained that the recently introduced ISO standard ISO 21001:2018 EOMS for higher educational organizations includes all requirements and guidance for use, and it is composed to have a vital impact on the critical elements of quality assurance in higher education. According to his study conducted based on USA HEIs, ISO 21001:2018 introduces an operating system model for educational organizations. The operating system model always clearly defines the key aspects of processes used in an organization. It is beyond the general quality practices and must adopt quality management structures continuously in their practises. The ISO 21001:2018 standard does not limit to any specific process approach, and many forms are available to choose from. Therefore the process management approach is much more practical since there is a transition in higher education from in-person classroom learning methods to technology-enabled education engaging with the array of ICT and online education modalities. The duration of ISO certification is also important. ISO certification has a limited duration, which is usually three years, and it needs interim surveillance audits to ensure whether the processes remain in place with quality. The shorter review interim period of ISO 21001:2018 over its accreditation is a demonstrative advantage for higher education due to the rapid changes occurring in certificate-based education and technological advancement (Coletto and Monte, 2019).

For all kinds of HEIs, the recent ISO standard (ISO 21001:2018) is recognized as the beginning of a cycle of change towards highly standardized approaches to quality in higher education (Schumann et al., 2019). According to Anttila and Jussila (2018), ISO 21001:2018 is evolving as a potential quality tool to define the quality assurance system of the guidelines and standards for quality assurance in the European context. The application of ISO 21001:2018 has been promoted vastly among many countries although the adoption of the new standard by HEIs does not appear to be widespread (Arief and Efgivia, no date; Abdulsalam, 2022; Syahrullah et al., 2022; Emanuel and Santoso, 2023) .

Challenges of adopting ISO in HEIs

According to the literature, the challenges of adopting ISO quality management systems in HEIs are mostly associated with internal institutional problems. It is worth identifying the major challenges in advance to mitigate the risk of being unsuccessful in ISO implications. The main challenge is the inadequate commitment from faculties and staff members as the majority consider ISO QMS as an additional workload rather than an improvement process. The lack of resources, physical infrastructure, and other facilities available for the complete implication of QMS is another challenge. The requirements of proper documentation control mechanism including easy access to all reference documents and maintaining a complete set of records is also a big challenge. Collaborations with external parties, some of which are not certified, becomes a barrier to establishing a standardized QMS. Inadequate communication among

both internal and external stakeholders lowers the effectiveness of QMSs (Kasperaviciute, 2012; Moturi and Mbithi, 2015).

Critical Success Factors (CSFs)

The identification of CSFs is essential for the sustainable implementation and maintenance of standardized QMS within HEIs. The management of the organization is responsible for identifying the CSFs in maintaining ISO-based QMS, especially during the post-certification period as it is more significant than during the certification period. (Wahid and Corner, 2009) have reported that human factors (including both management and employees), team collaboration, reward mechanism, continuous improvement, understanding of standards, performance evaluation and communication as the CSFs for ISO QMS maintenance. Ismyrlis and Moschidis (2015) state that human commitment, education and communication as the most critical CSFs. In addition to the above CSFs, Moturi and Mbithi (2015) have identified shared trust, responsiveness to staff and student necessities, regular review of QMS, training and sensitization for all kinds of employees, fair resolution of students' complaints and regular QMS meetings as the CSFs for better implementation and maintenance of QMS in HEIs.

ISO standards & Sri Lanka HEIs

Considering all 19 public universities operating in Sri Lanka, no university has obtained ISO certification for their overall QMSs. Instead, only a few departments and public institutions have certified their QMS under ISO 9001:2008 & ISO 9001:2015. On the other hand, among the 23 private sector HEIs for which the degree awarding status is granted by the Ministry of Higher Education, only less than five institutions have obtained ISO 9001:2008 and ISO 9001:2015 certification for overall university QMS. Therefore, altogether only less than 10 HEIs out of nearly 76 public and private higher educational institutions operating in Sri Lanka have certified their QMS under ISO 9001 standard, and still no institutions have certified their QMS following the recently published ISO 21001:2018 EOMS. The above approximate statistics were finalized by doing a web analysis due to the non-availability of an accepted data source to identify the ISO-certified institutions. In addition to the Sri Lanka Standard Institute (SLS), a few other international ISO certifying institutions also grant ISO certifications to Sri Lankan organizations.

4. CONCLUSION

The main goal of this study was to investigate the effects of adopting an ISO quality management system on Sri Lankan HEIs. The analytical review of existing literature confirms that adopting ISO 9001 QMS and ISO 21001:2018 EOMS in HEIs has proved a noteworthy growth with a potentially significant influence on quality accreditation processes.

Generally, HEIs can enjoy the common benefits of adopting ISO quality standards such as achieving consistent customer loyalty, continuous improvement of internal functions and enhanced quality of overall organizational performance. In view of the higher education sector, it has been notable that adopting ISO-based QMS would enable HEIs to the acquisition of competence through their main function of teaching, learning and research. Further, Standardized QMSs facilitate effective risk management and significant cost reduction by ensuring good coordination among all academic and administrative functions. The international recognition received from the ISO accreditation will help to build strong partnerships and linkages with different stakeholders and it would significantly contribute to attracting grants and funds, esteemed internship opportunities and strengthening local and international linkages and partnerships with professional demands.

The process management approach provided by the recently published ISO EOMS is more suitable to face the transition in higher education from in-person classroom learning methods to technology-enabled education engaging with the array of ICT and online education modalities. In addition, the shorter review interim period of ISO 21001:2018 over its accreditation is a demonstrative advantage for higher education due to the rapid changes occurring in certificate-based education and technological advancement.

Accordingly, the literature confirmed that the ISO-standardized QMS for educational organizations has established a significant favourable impact on critical elements of quality management processes in higher education. However, the institutions have to face the challenges associated with human factors, resources and physical infrastructure, documentation, management structures and communication in their journey of implementing and maintaining ISO standards. Therefore, the identification and consideration of CSFs are also essential for the successful implementation and maintenance of standardized QMS within HEIs.

5. RECOMMENDATIONS

In the Sri Lankan context, the implication of ISO quality management systems in HEIs is at a very lower level. Still, at least one Sri Lankan university has failed to sustain itself within the top 1000 universities in the world in terms of the globally accepted university rankings. Accordingly, adopting ISO QMS for Sri Lankan HEIs is much essential to go forward with international HEIs. This single study just provides an energetic basis for further discussions. More opportunities, therefore, exist for further studies to contribute to satisfactory ISO adoption in Sri Lankan HEIs.

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SOCIO-ECONOMIC IMPLICATIONS OF DOMESTIC VIOLENCE IN THENMARADCHI DIVISIONAL SECRETARIAT IN JAFFNA DISTRICT

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ABSTRACT

Domestic violence against women is one of the most contemporary social issues in Sri Lanka. This study aimed to identify the socioeconomic implications of domestic violence experienced by women. All 107 women were selected in Thenmaradchi Divisional Secretariat. The mixed method research design was undertaken with the help of a questionnaire survey and interviews. The Chi-square for univariate analysis was employed to analyze quantitative data with the usage of SPSS version 21 and qualitative data were analyzed thematically using the thematic analysis. According to the results, Hinduism (98.1%) was the predominant religion and 24.3% of the respondents' age range was 26-30 years. The majority of the victims (54.2%) were educated up to secondary educational level. Wage labour was the primary livelihood of many women and most of the respondents' monthly income was less than 20,000 Sri Lankan Rupees. There was a significantly high status between economic domestic violence and the variables including education ($p<0.000$); occupation ($p<0.000$) and income ($p<0.000$). Further, financial instability, low income, financial insecurity, unemployment, debt, poverty, low level of living standards, helplessness, lack of social recognition, and lack of social support were the significant economic and social impacts on women. In addition, stress, fear, tension, low self-esteem, and eating and sleeping disorders were the major psychological impacts on women. Additionally, cultural norms, fear, and stigma often cause women to stay silent about their experiences with abuse. Most of the women used coping mechanisms to cope with their implications. The research concludes that psychological implications were the most severe implication among the participants. This study suggests that vulnerable communities should be identified and services such as counselling and legal aid should be made easily accessible.

KEYWORDS: *Socio-Economic problem, Dowry, Sexual Violence, Domestic violence, Vulnerability*

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1. INTRODUCTION

Violence against women remains a significant contemporary social issue that can result in physical harm as well as long-term psychological issues including anxiety, depression, antisocial behaviour, suicidal thoughts, reduced self-esteem, social alienation, and inability to provide for themselves and their families. Further complications may include gynaecological, gastroenterological, and cardiovascular symptoms (Colorado-Yohar *et al*., 2016; Jack *et al*., 2018; Kulwicki *et al*., 2015; Lafta, 2008; Niolon *et al*., 2017). Additionally, domestic violence leads to a decrease in healthy life years for women of childbearing age and fatalities (*Alhabib et al.*, 2010; Niolon *et al*., 2017).

Domestic violence is a significant public health issue. It poses serious challenges that need to be addressed in Sri Lanka and broadly refers to any type of physical, sexual, emotional, or psychological abuse perpetrated by any member of the household (Bandara *et al*., 2022). Unfortunately, these numbers have been increasing during the economic crisis due to a variety of reasons. The Sri Lankan economic crisis causes reduced electricity, fuel, and cooking gas consumption, food shortage, poverty, and cancellation of critical surgeries in the country (Hovan George *et al*., 2022). The cost of living crisis in Sri Lanka has brought many impacts on people. The biggest dilemmas experienced by women were the feeling of being victims.

Domestic violence refers to "any act of gender-based violence that results in or is likely to result in physical, sexual or psychological harm or suffering to Women. Including threats of such acts, coercion, or arbitrary deprivation of liberty, whether occurring in public or private life" (United Nations, 1993). According to Sri Lanka's Prevention of Domestic Violence Act No. 34 of 2005 (Oct. 34 August 2005) "Domestic violence is any emotional abuse committed or suffered by an intimate partner within or outside the home environment, arising out of a personal relationship between the victim and the intimate partner". Based on the Women's Wellbeing Survey conducted by the Department of Census and Statistics in 2019, 20.4% of Sri Lankan females out of a population of 51.6% were victims of domestic abuse (Women's Wellbeing Survey, 2019).

This study has been based on the real-life experiences and voices of women who were victims of violence during the rising cost of living crisis in Thenmaradchi Divisional Secretariat. At present, the large number of domestic violence cases in the study area has been identified as a serious problem. The women face impacts such as financial strain, low income, financial insecurity, unemployment, inability to repay loans, poverty, declining standards of living, helplessness, sexual exploitation, and lack of social support, tension, low self-esteem, stress, eating and sleeping disorders. Also, women were inclined to stay silent about their abuse experiences due to certain cultural values, fear, lack of knowledge, lack of professional support, acceptance of abuse, and stigma. Among women who experienced domestic violence in this study site, only a small proportion have sought help themselves for the violence from the Divisional Secretariat office, hospitals, and court. Therefore, it was identified as a public health concern and this study was conducted by the researcher to investigate it. Also, it will help future researchers to carry out in-depth analyses to establish the relationship between socio-economic impacts and associated factors of women who had domestic violence. As no such study has so far been conducted in this area, the study is expected to fill an important research gap.

2. METHODOLOGY

The study area

Source: Divisional Secretariat Report (2022)

The study was conducted in Thenmaradchi Divisional Secretariat area in Jaffna district within the Northern Province of Sri Lanka. There are 15 Divisional Secretariat Divisions in Jaffna district and each consists of 60 Grama Niladhari Divisions (Themaradchi Divisional Secretariat report, 2022). In the Eastern border of this area is the Pachchilaippalli Divisional Secretariat area. In the Western border are Navatkuli Semmani Bridge and Upparu Sea water. In its Northern border are Thondaimanaaru sea water and the Vadamaradchi South-west Divisional Secretariat area. In its Southern border are the Jaffna Peninsula and the Poonagari Divisional Secretariat area. The area of Thennamarachchi Divisional Secretariat is 232,19 km^2, and according to its census for November 2021, it has a population of 73,394 in 22,889 families (Divisional Secretariat Report, 2022).

This community-based study was conducted as a mixed-method research design to identify the socioeconomic implications of domestic violence against women, and some related factors (quantitative) and real-life experiences of such violence (qualitative) simultaneously in the study area. According to the Jaffna District Secretariat, there were 246 incidents of domestic violence in Jaffna district in 2021 (District Secretariat Report, 2022). Based on the registered cases in Thenmaradchi Divisional Secretariat and court of Chavakachcheri, in total, there were 107 responses to the self-administered questionnaire survey, which were from women who had experienced domestic violence in the last 12 months in 2021 (Divisional Secretariat report, 2022). Further, 15 interviews were conducted in the study area.

Primary data was gathered through a self-administered questionnaire and interviews. To achieve the aim of this study, a self-administered questionnaire was developed using open-ended questions and multiple-choice questions. Multiple choice questions provided a list of answers of forms of domestic violence and impacts of domestic violence from which the respondent could choose, and it was aimed to exhaust all possible answers. In this case, the researcher includes an "Other, please specify" answer choice to reduce bias in the study. The related research areas can be broadly analyzed by conducting interviews. By using interview method, researchers could have a holistic view of the meaning behind the phenomenon of domestic violence and explore social processes in rich and complex details through this study. Secondary data was collected from the Divisional Secretariat, District Secretariat, research articles, journals, and website data. Victims of domestic violence in the community were included in the research after obtaining permission from the Divisional Secretariat. Informed verbal consent for attending the study was also taken from all participants before conducting interviews, once the purpose and the objectives were explained by providing a written consent form (information sheet) before the questionnaire. Confidentiality was maintained during the data collection and they were ensured that information collected would be used only for the study. And, the right to individual dignity was respected. The data generated were stored and kept locked in a protected environment.

Data analysis

The quantitative data collected through a questionnaire survey were analyzed using descriptive statistical methods and a chi-square test with the usage of SPSS (version 21), and the qualitative data were analyzed utilizing thematic analysis. In the initial step, axial coding (initial reading of texts) was critical to understand the content and core notions drawn from various aspects of domestic violence on women. Then, open coding (coding the text after repeated reading) began with the collection of raw data. In this phase, researchers generated 57 basic codes after the comprehensive analysis of the responses. In the final stage, selective/theoretical coding (generating themes through codes) was completed after the core concepts emerging from the coded data categories and subcategories have been identified through axial and/or open coding. First, the data were analyzed descriptively using means and standard deviations for continuous variables and counts and percentages for categorical variables. To study the forms of domestic violence in each aspect of family life, the chi-square test was used for univariate analysis. All values such as influence factors and forms of domestic violence were calculated by using the chi-square test, statistical significance was set at $p<0.05$. To evaluate reliability

of the variables, the Cronbach's alpha coefficient was set at more than 0.6.

3. RESULTS

Testing for Validity

The researchers utilized the Expert Validity technique to establish the validity of the data collection tools.

Testing for Reliability

A reliability test was done by utilizing Cronbach's alpha value using SPSS. Bernstein, *et al* (1994) confirmed that the standard value for Cronbach's alpha could be more than 0.6, which was previously recommended by Bagozzi (1988). Table 1 shows the reliability values and number of items for each variable used in this research study.

Table 1: Reliability for each variable

Variable	Cronbach's Alpha	No of items
Social impacts	.668	7
Economic impacts	.643	7
Psychological impacts	.879	7
Coping mechanisms	.727	8

Source: Survey Data (2022)

Table 2: Sociodemographic factors of participants

Variables	Frequency	Per cent (%)
Age (years)		
20-25	17	15.9
26-30	26	24.3
31-35	16	15.0
36-40	23	21.5
41-45	10	9.3
46-50	7	6.5
51-55	2	1.9
56-60	5	4.7
>60	1	0.9
Total	107	100.0
Religion		
Hindu	105	98.1
Christians	2	1.9
Total	107	100.0
Educational level		
Primary Education (1-5)	6	5.6
Secondary Education (6-11)	58	54.2
G.C.E A/L	32	29.9
Bachelor's degree and above it	9	8.4
Technical college	2	1.9
Total	107	100.0
Occupation		
Self Employment	9	8.4
Business	1	0.9
Wage labour	28	26.2
Government job	12	11.2
Private job	3	2.8
Home working	15	14.0
No occupation	39	36.5
Total	107	100.0
Monthly total income (Rs)		
Less than 10000	16	15.0
10001-15000	21	19.6
15001-20000	24	22.4
20001-25000	9	8.4
25001-30000	8	7.5
30001-35000	9	8.4
More than 35000	20	18.7
Total	107	100.0

Source: Survey Data (2022)

Table 2 shows the socio-demographic factors of participants. In the study population (107), the majority of the women (24.3%) belonged to the age group between 26 and 30, and the smallest minority of the participants (0.9%) were over the age of 60. The age range of the participants varied from 20 years to 64 years while the mean (standard deviation), median, and mode were 35 (9.616), 33.78, and 27.85 respectively. The vast majority of the participants (98.1%) were Hindu and the majority of the participants (54.2%) had studied up to the ordinary level, while 36.5% of the participants were unemployed. The total income of the majority of them (57%) was Rs.20000 Sri Lankan Rupees and the average monthly income per family was 12683 Sri Lankan Rupees.

Table 3: Perpetrators of Domestic violence

Perpetrators	Frequency	Per cent (%)
Spouse (Husband)	107	45.1
Father-in-law	17	7.2
Mother-in-law	90	38.0
Brother-in-law	9	3.8
Sister-in-law	14	5.9
Total	237	100.0

Source: Survey Data (2022)

Table 3 indicates that in the overall prevalence of any form of violence during the rising cost of living crisis among the study population, husband (45.1%) was the

main perpetrator followed by other family members. Nearly 38% percentage of victims were more likely to experience violence from their mother-in-law.

"My husband depends on his mother. He doesn't have his own opinion; he follows his mother talking after that he beats me in front of others. The main reason for the fighting between us was his mother. She desires to separate us" (Case study, 07).

Table 4: Forms of economic violence

Economic violence	Frequency	Per cent (%)
Restricting access to money	62	30.1
Preventing from work	55	26.7
Refusing to give food	19	9.2
Controlling their income	44	21.4
Forcing into debt	2	1.0
Forbidding to work hours	24	11.6
Total	206	100.0

Source: Survey Data (2022)

Table 4 illustrates that the majority of the respondents (30.1%) were unable to access money, which was the main economic form of domestic violence. A few women (1%) were forced into debt by their perpetrators. The following case studies indicate these:

"He goes to earn money. He brings some goods for family needs. But those goods are not enough for our family during the current cost of living crisis. So, I work in a hospital as a caring person. Now I buy the goods and things. He doesn't like to go to work. He scolds and fights with me because I go to work" (Case study, 03).

"He doesn't like to work hard usually. In the situation where I am a member of both the Samurdhi and Community Centre in our village, he will pressure me to get a loan. However, if I am not a member, he will criticize and confront me with malicious intent. Now violence is increasing at home due to crisis" (Case study, 09).

Table 5: Association between economic violence and selected independent variables

Variables	X^2	df	P value
Age	11.131	8	=0.194
Education	22.447	4	<0.000
Occupation	25.488	6	<0.000
Income	26.125	16	<0.000

Source: Survey Data (2022)

The results of the chi-square test showed in Table 5 that socioeconomic factors such as education ($p<0.000$), occupation ($p<0.000$), and income ($p<0.000$) were significantly higher in economic violence. There was no significant association between age ($P=0.194$) and economic violence.

Table 6: Forms of social violence

Social violence	Frequency	Per cent (%)
Stopping from seeing family	76	19.5
Forcing to spend time at home	97	24.9
Not being allowed outside	103	26.4
Not being allowed to functions	93	23.8
Telling lies about me to family	7	1.8
Deliberately doing bad things	14	3.6
Total	390	100.0

Source: Survey Data (2022)

Looking at social forms of domestic violence in Table 6, not being allowed outside had been experienced by 26.4% of women and 1.8% of victims reported that telling lies about themselves to family was the social form of domestic violence during rising living costs. The following case studies reveal that:

"He doesn't allow me to maintain a relationship with my mother, he always forces me to spend time at home. He always calls them over the phone for scolding with bad words" (Case study, 08).

"When the rising cost of living crisis started, I was ecstatic. I suffer from regular domestic attacks from my husband, and therefore couldnt neither move nor speak. I can't sleep properly and feel like I am stuck in my house. I have bitter arguments with him, he doesn't allow me to participate in any functions in our village, I don't know how to manage" (Case study, 07).

Table 7: Forms of physical violence

Physical violence	Frequency	Per cent (%)
Beating	97	16.0
Throwing objects	63	10.4
Pushing	80	13.2
Use of Weapons	74	12.2
Punching	52	8.6
Kicking	72	11.8
Pulling hair	66	10.8
Strangling	37	6.1
Arm and leg twisting	37	6.1
Sudden seizure	27	4.4
Stabbing by child	1	0.2
Keeping warm	1	0.2
Total	607	100.0

Source: Survey Data (2022)

Table 7 states that 16% of participants in the study were more likely to face physical violence such as beating. The following case studies depict it:

"This is the only torture for me is that whatever problem he has, he shows it to me. While standing, he throws and beats with objects, and speaks virtuously with slander" (Case study, 09).

"I am only beaten when I fight. He pushes and pulls my hair with his hands. I was in the hospital for a day due to strangulation" (Case study, 01).

Table 8: Forms of sexual violence

Sexual violence	Frequency	Per cent (%)
Using a sexualy derogatory name	61	67.9
Sexual harassment	10	11.1
Forcing sexual activities	4	4.4
Refusing to use condoms	11	12.2
Forcing sex during mensuration	2	2.2
Forcing sex in multiple times	1	1.1
Forcing sex in front of children	1	1.1
Total	90	100.0

Source: Survey Data (2022)

Table 8 denotes that most of the women (67.8%) were abused in the form of verbal abuse. The following themes show it:

"Using sexual language, preventing contraception, sexual harassment, engaging in extramarital sex, forcing sex during mensuration times, forcing to have sex five or six times a day and forcing sex while children are at home" (Key Informant Interview, 01).
"All his desires should be agreed to without time limit. Otherwise, he will talk me wrong" (Case study, 03).

"He stayed at Kilinochchi and went to work. When the children come after work, they will fight for his feelings if I do not agree with his desires. No idea about my family situation. I should go with him, this is what he has been doing regularly since the time of marriage" (Case study, 06).

Table 9: Forms of psychological violence

Psychological violence	Frequency	Per cent (%)
Harassment	34	8.4
Isolation	80	19.7
Silence	63	15.5
Coercion	74	18.2
Controlling	101	24.9
Threats	54	13.3
Total	406	100.0

Source: Survey Data (2022)

According to Table 9, the most common form of psychological violence was controlling (24.9%), isolating (19.7%), coercion (18.2%), and threatening (13.3%), while 8.4% was harassment. The following case study implies it:

"The rising cost of living crisis gave me a lot of time to stay home, my home has been like a prison, and staying home too long sucks. My partner controlled me due to different thoughts on financial strain. We fight more, I fight with my husband and beat the children in anger" (Case study, 06).

The findings also concluded that psychological violence is more frequent than other forms of violence. The following evidence supports the findings that in the study of Bandara *et al*., (2022) they focused when considering the diagram of 2018, it is seen that among the forms of violence, emotional violence was reported more than physical violence.

Table 10: Association between forms of domestic violence and income of participants

Forms of violence		N	(%)	
Economic violence	Yes	84	78.5	X^2=26.125
	No	23	21.5	df=6
	Total	107	100.0	P<0.000
Physical violence	Yes	91	85.0	X^2=6.054
	No	16	15.0	df=6
	Total	107	100.0	P=0.417
Sexual violence	Yes	64	59.8	X^2=17.315
	No	43	40.2	df=6
	Total	107	100.0	P=0.008

Source: Survey Data (2022)

According to Table 10, the forms of domestic violence, economic violence (p<0.000), and sexual violence (p=0.008) were statistically significant with the total monthly income of the family of participants who experienced domestic violence. Also, there was no significant association between physical domestic violence (p=0.417) and the total monthly income of participants' families.

Table 11: Impacts of economic violence

Economic violence	Frequency	Per cent (%)
Financial instability	107	26.7
Low income	91	22.7
Financial insecurity	104	25.9
Unemployment	20	5.0
Inability to repay the debt	79	19.7
Total	401	100.0

Source: Survey Data (2022)

Table 11 implies that the most common impact of economic violence was financial instability (26.7%). Financial insecurity (25.9%), low income (22.7%), inability to repay loans (19.7%), and unemployment (5%) were economically forced on women during the cost of living crisis. The following qualitative data depicts the same:

"Without a doubt, we know the current economic crisis has caused difficulties for everyone, changing their lifestyle and how family members interact with each other. And it also creates more violence among family members, particularly in this area where women are involved in domestic violence due to reduced income" (Key Informant Interview, 01).

"He has brought a refrigerator. We must pay the loan every month. But he doesn't pay it. I paid the borrowed money. If I talk about the loan, he will start to beat up me" (Case study, 04).

"During the lockdown period, we stayed at home with my family members and we were unable to go outside and buy the needed things. We became more intolerant and depended on others for meals" (Case study, 09).

The current study concluded that most of the victims of domestic violence are impacted by financial instability and financial insecurity in the study area. The study done by Women's Aid (2022) reveals similar findings that women who are affected by domestic abuse have experienced increased financial instability, cost of food, cost of fuel, reduced income, and debts.

Table 12: Impacts of social violence

Social violence	Frequency	Per cent (%)
Poverty	103	27.9
Declining living standards	94	25.5
Helpless	67	18.2
Lack of social recognition	23	6.2
Lack of social support	82	22.2
Total	369	100.0

Source: Survey Data (2022)

The prevalence of impacts of social violence in Table 12, poverty was higher (27.9%) and lack of social recognition (6.2%) was lower. Further, declining living standards (25.5%), the helpless (18.2%), and lack of social support (22.2%) also had significant social impacts on women in the present study. The qualitative data show that,

"The economic crisis has taken a toll on vulnerable people, especially those with women, who in many cases, have had to take on various roles such as caregiver, income earner, and parent with few opportunities for breaks. Many women are also expected by men to work from home with their work responsibilities. It leads to poverty and creates domestic violence in family bonds" (Key Informant Interview, 01).

"Instead of having three meals a day, we reduced them to only two; breakfast and dinner. It was not easy for the children to adjust. It affects their healthy life" (Case study, 06).

"I know in this area people have heard about our family problems. It will be very hard to choose a life partner for my daughters in future" (Case study, 01).

"I began spending a lot of time with my family members. Although making breakfast and dinner are part of my daily routine, I spend a lot of time sitting and watching Television, but I don't have family support" (Case study, 05).

The present study concluded that most of the victims are highly affected by poverty in a cost-of-living crisis. This finding also agrees with the following study by Hovan George *et al.*, (2022) carried out concerning the impact of the rising cost of living on women, the Sri Lankan economic crisis causes food shortage and poverty in the country.

Table 13: Impacts of psychological violence

Psychological violence	Frequency	Per cent (%)
Tension	103	17.0
Fear	67	11.1
Stress	101	16.7
Anxiety	56	9.2
Low self-esteem	99	16.3
Inability to trust others	73	12.0
Eating and sleeping disorder	107	17.7
Total	606	100.0

Source: Survey Data (2022)

Table 13 illustrates that most women (17%) suffered from tension and fewer (9.2%) suffered from anxiety. Other psychological impacts were faced by victims, such as 16.3% of low self-esteem, 17.7% of eating and sleeping disorders, 16.7% of stress, 12% of inability to trust others, and 11.1% of fear. The following case studies indicate that:

"He doesn't drink and smoke at home, but always fights and scolds me, which affects me mentally" (Case study, 10).

"Several times I was deeply frustrated and had tension due to not tolerating his torture. Then I gave up that thought" (Case study, 02).

"I cry when he engages in fighting. I don't eat food regularly, get proper sleep, and think deeply. When he beats me, I go out and return home for the children after he goes out. But he threatened me, I was afraid and ran away" (Case study, 03).

"I have an emotional sense that I don't have a profitable and meaningful life, I feel bad about my family relationships" (Case study, 09).

Tension and eating and sleeping disorders are the main impacts of psychological violence found in this study area. The impact of psychological violence is mostly invisible. These affect mental health and harmonious relationships. The findings concluded that most of the women are highly influenced in terms of psychological impacts on family relations rather than other impacts in the Thenmaradchchi Divisional Secretariat area.

Table 14: Formal help sources were sought by women

Formal help sources	Frequency	Per cent (%)
Police stations	87	32.0
Court	75	27.5
Divisional Secretariat	63	23.1
Conciliation board	22	8.1
Grama Niladhari	22	8.1
Women In Need	1	0.4
Intervention social centre	1	0.4
Care centre (Natpu illam)	1	0.4
Total	272	100.0

Source: Survey Data (2022)

Table 14 shows that most of the participants (23.3%) sought help from formal sources for help such as the police, and a minority of the participants (0.3%) sought help from specialized help centres and from medical and social services. The following Key Informant Interview reveals it:

"Some refuse to file a complaint with the police because of their social norms; Because there is a fear of not being able to get married if you go to the police, there is also a ritual of not having a husband to take care of the children" (Key Informant Interview, 01).

Remedies received from formal help sources

The provision of both informal and formal assistance to women who are victims of domestic violence and abuse has the potential to enhance their safety and health outcomes. The remedies were identified by participants from the formal help sources such as, help to strengthen family unity, not satisfied with the solution, no solution received, children's learning equipment and clothes were provided through the Divisional Secretariat, the case is ongoing, violence has reduced to some extent, divorce has been sought, debt problem has been solved, livelihood assistance has been provided through the Divisional Secretariat, the husband has been punished, the husband's alcohol consumption has decreased, the children have returned to normal, monthly allowances and psychological counselling has been provided.

"Those who are most affected by domestic violence are given six months of medical treatment at Chavakachcheri hospital, six months of psychological counselling at the Divisional Secretariat, and six months of imprisonment by the courts to the perpetrators of domestic violence" (Key Informant Interview, 01).

"I sought help from the police station, the police asked me to live together with the children. But he did not accept it, he refused. Then the police sent us to go to the Divisional Secretariat. I went there but he didn't come. In the Divisional Secretariat, they inquired about everything. They also advised us to be united as a family" (Case study, 07).

Assistance for participants who experienced domestic violence

Various assistance was provided to victims of domestic violence, their husbands, and their children through the Divisional Secretariat, women's organizations, and other community-level organizations. The following qualitative data reveals the same: *"Providing assistance to children of victims experienced by domestic violence to follow their education, giving psychological counselling and visiting their homes. Assistance is provided by the Divisional Secretariat, such as sending to the WIN social organization. In addition, the "Kurundham" social organization also provides bits of advice, those who are addicted to alcohol and drugs for fourteen days, given yoga training, psychological counselling for 6 months, and sent to a clinic in hospital" (Key Informant Interview, 01).*

"He beat me once. This incident reached the Grama Niladhari, he came to my home and made peace to this incident" (Case study, 08).

Table 15: Coping mechanisms used by victims to cope with impacts of domestic violence

Coping mechanisms	Frequency	Per cent (%)
Keeping calm	12	4.3
Leaving home	34	12.2
Going to work	45	16.2
Being patient	67	24.1
Reducing daily living costs	97	34.9
Seeking help from neighbors	23	8.3
Total	278	100.0

Source: Survey Data (2022)

According to Table 15, the majority of the victims (34.9%) reduced daily living costs due to the rising living costs and the minority of women (4.3%) kept calm while violence occurred in their homes. The following qualitative data represent it:

"In low-income families due to poverty, women seek help from neighbors when they are dissatisfied with their lives. And, while violence occurs at home, most victims are being silent because of their culture" (Key Informant Interview, 03).

"I have no idea about when it will end. Now I am reducing the cost of food and medicine. I eat little vegetables. I save money for children's future lives" (Case study 09).

4. DISCUSSION

This study aimed to identify the socioeconomic implications of domestic violence experienced by women in Thenmaradchi Divisional Secretariat in Jaffna district. Regarding the percentage distribution of Socio-demographic study sample features, the data reveal that the young ages of the women are a significant factor contributing to a rise in violence. At a young age, women have the fear of the stigma of society and family, and being forced to be patient can have negative psychological and emotional effects. This result is in agreement with the study of Walker *et al*., (2021) who mentioned with similar socio-demographic data that the young age of women and a large age difference are very important factors that cause increase in violence. When they are in younger age, girls are afraid of the stigma of society and family, and being forced to remain silent can lead to an increase in the abusive behaviours associated with mental and physical health consequences.

Also, low level of education has been found as another factor of violence in this study, which is significant in qualitative and quantitative (54.2%) studies. The findings were supported by Shayestefar *et al*., (2023) that lack of knowledge and low level of education have been found as other factors of violence in this study, which is prominent in both qualitative and quantitative studies. Balasekar, (2021) also stated that men and women who have not had the opportunity to question gender roles, attitudes, and beliefs cannot change such things. Women cannot assert their rights if they are ignorant of them.

The present study shows that women suffering from domestic violence face different types of violence from their husbands. These findings align with those of population-based research on domestic violence experienced by women conducted in Iran (Manouchehri *et al*., 2022). Another similar study by Dammeyer and Chapman, (2018) conducted in Denmark also supported the findings that people with disabilities and IPV face different types of violence from their husbands.

The current study results show that psychological violence is more frequent than other forms of violence. The following evidence supports the findings that in the study of Bandara *et al*., (2022) they focused when considering the diagram of 2018, it is seen that among the forms of violence, emotional violence was reported more than physical violence, and, the study by Manouchehri *et al*., (2022) in Iran, supports this finding, that psychological violence is the second most common violence on women.

In terms of the distribution of women based on the impacts of domestic violence, the present study found that most of the victims of domestic violence are impacted by financial instability and financial insecurity in the study area. The study done by Women's Aid (2022) reveals similar findings, that women who are affected by domestic abuse have experienced increased financial instability, cost of food, cost of fuel, reduced income, and debts.

This study depicts that most of the victims are highly affected by poverty in a cost-of-living crisis. This finding also agrees with the following study by Hovan George *et al.,* (2022) carried out concerning the impact of the rising cost of living on women, the Sri Lankan economic crisis causes food shortage and poverty in the country. In this study, a significant relationship was seen between the prevalence of domestic violence and the variable of participants' income. The following study by Manouchehri *et al*., (2022) mentions and supports it, in Iran, where a significant relationship was seen between the overall prevalence of domestic violence and the variable of participants' income. These scenarios are very close to the present study and give valuable insights into the planning and operationalization of the present study. There is no such previous study in view of the socio-economic implication of domestic violence on women in the study site. Therefore, these findings also appear to be consistent with the present study.

5. CONCLUSION

The cost-of-living crisis is seriously affecting female victims of domestic violence in Sri Lanka. The increased cost of living has resulted in women being more fearful of leaving violent situations. Economic, social, and psychological impacts have become rife on victims in the study area during the crisis, such as financial instability, low income, financial insecurity, unemployment, inability to repay debts, poverty,

declining living standard, and helplessness, lack of social support, tension, low self-esteem, stress and eating and sleeping disorders. Most women used coping mechanisms to cope with the impacts of the rising cost of living. The present study recommends future studies to assess the implications of the rising cost of living on victims of domestic violence.

Vulnerable communities should be identified and services like counselling and legal aid should be made easily accessible and free of charge.

Efforts should be made for the proper and effective enforcement of existing laws related to women.

Livelihood assistance should be given according to the background of the victims of domestic violence.

Lists of nongovernment organizations and other governmental organizations dealing with women's issues should be made known to the public and should create awareness of domestic violence.

Police need to be sensitized to treat domestic violence cases as seriously as any other crime.

Children of afflicted women should get attention to improve their education and social development.

Women are more vulnerable because of their limited voice in the community and household decision-making. Family system theory is most applied to this study. In this study area, most of the victims' life partners are engaging in wage labour. They do not get enough money during the rising cost of living crisis. Because of that, they took loans to fulfill their needs and they also have low job satisfaction. These situations create stress on domestic violence perpetrators.

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PERMA PROFILER: ADAPTATION TO SINHALA

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ABSTRACT

Recent history has seen an increased interest in wellbeing. This interest has been observed in clinical settings as well as at the level of state policies and at corporate levels. Following this interest, many models of wellbeing have been developed. The PERMA model of wellbeing was a more recent development forwarded by Martin Seligman, which measures the five core elements of wellbeing that are referred to as PERMA. The acronym stands for positive emotion, engagement, relationships, meaning, and accomplishment. This model is based on the conceptual framework of positive psychology. PERMA profiler is a psychometric measure of wellbeing, which is based on the PERMA model. This tool has been gaining recognition as a reliable and valid tool for the measurement of wellbeing, especially in occupational settings. The current study aimed to adapt the PERMA profiler to Sinhala, which is the language used by the majority of Sri Lankans. The tool was translated by two psychologists and was synthesised to one single translated version by a panel of three experts, and it was evaluated for clarity and relevance by another panel of experts. The pre-testing was done in a sample of 15 individuals and the back translation was carried out by a professional translator. The adaptation was completed in consultation with the original authors of the scale. Results indicated that the Sinhalese adaptation of the PERMA profiler was deemed to be well-suited to be used with Sinhalese speaking populations with an average education.

KEYWORDS: *PERMA model of wellbeing, Sri Lanka, adaptation, Sinhala*

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1. INTRODUCTION

What is Wellbeing?

Recent discussions on wellbeing at the scholarly level and political levels have concentrated on making well-being a state policy for the governments. Scholars argue that if mental illnesses are caused by the loss of wellbeing, governments have the responsibility to take measures to improve public wellbeing as the loss of it would lead to increased costs in the treatment of mental illnesses (1). This is a departure from the traditional model of using economic indicators as the sole policy of development. This also shows the impact of the recent surge of interest in wellbeing has had at the macro level of society (2,3). The wellbeing budgets of the United Kingdom and New Zealand are good examples for this (4,5).

Importance of wellbeing in psychology

Before the 1950s, psychology was mostly based on abnormal and clinical approaches; however, later on, it shifted to humanistic approaches such as person-centred therapy and Maslow's hierarchy of needs. Then, the psychological concepts were expanded to the wellness of an individual, group, or society at the macro or micro level from a positive psychological perspective.

The need for a wellbeing approach arose because disciplines that were focusing on human psychology were narrowly focused on an illness approach rather than on a wellness approach. Wellness and wellbeing approaches are considered an important milestone in expanding the understanding of human psychology, which was long confined to the narrow illness focus. Following this paradigm shift, there has been a proliferation of psychometric tools for the measurement of wellbeing. As wellbeing is a multifaceted concept, there are many conceptualizations of wellbeing in the current research literature. Psychometric tools have also been developed along with these different conceptualizations (6).

There are two prominent conceptual views of wellbeing. One is the Hedonic view of wellbeing. It focuses on the subjective feelings of positivity. The other is the eudaimonic view of wellbeing, which conceptualises wellbeing as living in a "flourishing" or well-developed manner. This view conceptualises wellbeing in terms of pursuing goals and activities that are consistent with one's values and identity (7), yet there are criticisms on the use of these models as who is considered as an optimally functional human being can be different from person to person.

Additional models of Wellbeing which do not fall into both the above-described models have been forwarded in the recent past. One such theory is the theory of flow states. Mihaly Csikszentmihalyi was the first person to forward these concepts in the 1960s (8). Flow states are believed to be characterised by higher levels of engagement, concentration and pleasant feelings. Positive antecedents of flow states in the workplace are shown to be job resources such as social support, opportunities for professional development, and supervisor coaching (9).

Another model is the PERMA model forwarded by Martin Seligman, based on the model of positive psychology (10). PERMA stands for positive emotions, engagement, relationships, meaning and achievement, which are considered as the five pillars of wellbeing. There is increased research evidence for the validity of this model as the field of positive psychology continues to grow.

a. PERMA model of wellbeing

The PERMA model of wellbeing springs from the conceptual assumptions of positive psychology. One of the main tenets of positive psychology on wellbeing is that it is not simply the absence of negative functioning. In addition to the absence of negative functioning, "flourishing" of the individual is seen as wellbeing. The state of flourishing is defined as a dynamic, optimal state of functioning. Flourishing is seen as the outcome of optimal functioning in many different domains (11).

It is important that these abstract concepts of wellbeing are translated into more specific, measurable ones and when measuring them, intervene for improving wellbeing. Martin Seligman delineates positive emotions, engagement, relationships, meaning and

engagement as the measurable constructs of Wellbeing. The acronym PERMA stands for these five concepts (12).

b. PERMA profiler

The PERMA profiler is a psychometric measure for the measurement of wellbeing, which has been forwarded by Julie Butler and Magaret L. (11). It has been widely used and has been adapted for being used in multiple settings with multiple populations (13, 15) PERMA profiler has particularly been identified as a reliable and valid tool to be used in occupational settings. In addition to this, it has been used as a measure of wellbeing, particularly in occupational settings across many cultures (15-18). The website of the PERMA profiler lists 13 adaptations to other languages. Among these are the Asian languages of Korean, Japanese and Chinese.

The PERMA profiler consists of 23 items. There are 15 questions pertaining to the 05 PERMA domains of positive emotions, engagement, relationships, meaning and engagement. Each domain is measured via 03 questions. Other questions measure the domains of health, negative emotion, loneliness and overall happiness. These act as filler questions in providing further details pertaining to the wellbeing of the test taker.

Importance of PERMA profiler in the Sri Lankan context

Several well-being scales have already been validated to Sinhala. The WHO5 wellbeing index, which is a short rating of wellbeing, has been validated to Sinhala. Yet, WHO 5 is seen as more suitable to be used in high income settings. It is quite useful as a quick, short measure in busy settings (19). In addition, the Warwick, Edinburgh mental wellbeing scale has also been adapted to Sinhala. It is based on Hedonic and eudaimonic conceptualizations of wellbeing (20). Nevertheless, The PERMA profiler is the first psychometric tool on wellbeing which has been adapted to Sri Lanka, which is based on the positive psychological concepts. The PERMA model is one of the latest psychological approaches which emphasises mental wellbeing beyond the absence of mental illness. As the tool has a wide recognition of its validity, the authors believe that it would be a value addition to the repertoire of wellbeing measurements in Sinhala for Sri Lanka. Further, this model has been identified as a valuable framework for assisting professionals to measure wellbeing. Thus, having a tool that measures these core dimensions in the Sri Lankan population is important. Therefore, the current study adapted the PERMA profiler for Sinhala speakers of Sri Lanka.

The current adaptation study received ethical clearance from the Ethics Review Committee (ERC) of the faculty of medical sciences of the University of Sri Jayewardenepura.

2. METHODOLOGY

a. Translation

The PERMA profiler was translated into Sinhala by two psychologists from Sri Lanka after obtaining the necessary permissions from the original authors of the scale. One was the principal investigator who is a licensed clinical psychologist. The second was a Forensic psychologist, holding a master's degree in forensic psychology. Both have experience working with clinical populations and have been involved in many initiatives related to wellbeing both at the clinical and research level. Both translators were fluent in both Sinhala and English languages. Two independent Sinhala translations were produced by the translators as the first step of the adaptation.

b. Committee synthesis

The two translations were presented to an expert panel of three psychologists. The panel consisted of two counselling psychologists and one clinical psychologist. The experts were requested to compare the two translated items for each original item and rate the relevance of the two translated items in a Likert scale. The Likert options ranged from 1-5 with scores of 01 for least relevant, 02 for less relevant, 03 for modest in relevance, 04 for relevant and 05 most relevant. In relation to the measurement of the relevance of the translated items, an average of 12 was expected. A score of 12 was equivalent to a score of 04 (relevant) from each panel member. Items which received a score below 12 were identified as low score

items. When there were similar scores for the two translated items or when both items received low scores, discussions were held with the expert panel as well as language experts outside the expert panel and the items were modified, until the desired scores were obtained. When equal scores were obtained by both translated items, the two translators discussed with each other and selected the item which was deemed more appropriate.

c. Expert panel evaluation for clarity and relevance

The final translated Sinhala version of the PERMA profiler was presented to another expert panel of three members to gauge the clarity and relevance of the items. This panel consisted of three psychologists: one clinical psychologist, one counselling psychologist and one applied psychologist. Content Validity Indices (CVI) for the scale and individual items were calculated based on these ratings.

d. Comprehension test

A convenient sample of fifteen participants were recruited for the comprehension test. As the adapted scale is expected to be used with the Sri Lanka army, the test is expected to be understood by all categories of the army personnel. As per the website of the Sri Lanka army, the minimum educational criterion for recruitment is having an education up to grade 10. Therefore, 05 individuals with General Certificate of Education, Ordinary Level (G.C.E. O/L) qualifications were included in the sample. O/L examinations are held after the completion of 11^{th} grade in Sri Lanka. Therefore, these individuals were seen as close in knowledge and skills to the minimum educational criterion required by the Sri Lanka army. Other than that, 04 individuals with General Certificate of Education, Advanced Level (G.C.E. A/L) qualifications, 03 individuals who were undergraduates and 03 individuals with master's degree qualification were included in the sample. Accordingly, a total of 15 individuals participated in the comprehension test and all of them were residents of Colombo district.

Participants rated the items on a Likert scale of 1-5 on the ease of comprehension. 1 was indicated as the lowest level of comprehension (I did not understand anything) to 5 being the highest level of comprehension (I completely understood).

e. Back translation

The final Sinhala translation of the PERMA profiler was forwarded to a sworn translator for the purpose of back translation. The translator was contacted via an online advertisement. Upon receipt of a quotation for the translation the Sinhala PERMA profiler was emailed to the translator with proof of payment. The translator emailed the authors the English translation of the PERMA profiler in three days' time. A copy of the back translation was sent to the original authors for their feedback.

f. Materials

At all stages of the adaptation, free google forms were designed to obtain ratings. Participants who agreed to participate were sent the google form link after obtaining consent. Whenever meetings were required, these were done online via Zoom. These measures were employed as the study took place when the risk of COVID – 19 infection was high.

3. RESULTS AND DISCUSSION

In the course of synthesising the two forward translations of the PERMA profiler, there were modifications proposed by the expert panel. For eight items the panel requested changes in the choice of Sinhala words. Complete modifications of items were not required. There were two items which received equal scores. The two translators decided on the final item to be selected after a discussion as to which item would be easily understood and would convey the original meaning best. Five low score items were identified. These were modified after discussing with the panel members, and language experts from a state university until a minimum score of 12 was obtained from the panel members.

After presenting the translated version to the second expert panel, CVI scores were calculated. The S-CVI was 0.72. All items received an ICVI score of 0.5 or above. Ten items received an ICVI score of 01, and ten items received an ICVI score of 0.6. The rest of the

items received an ICVI score of 0.5. The total number of items were 27, and this included the title and response choices of the scale which were translated to Sinhalese. Items which received less than 01 were modified with the expert suggestions.

During the comprehension test, the majority of the items had received a score of above three on their level of comprehension. The lowest score received was 03, which was only received by less than five items.

When the back translation was presented to the original authors, they proposed edits on seven items. As per their suggestions, modifications were made and the scale was finalised. The revised back-translation was presented to the original authors. During the current study which was aimed at culturally adapting the PERMA profiler to Sinhala, the researchers faced a few challenges. The main challenge was finding suitable Sinhala words to generate the meaning provided in the original scale. It was to translate the English words denoting emotions to Sinhala. It is speculated that this may be because emotions are not very frequently discussed in Sinhala cultural context. Yet, this is merely a speculation and needs to be studied further to be evidence based. During the discussions held with the expert panels in deciding upon the final terms denoting emotions, the most frequent observation was that a single term may have multiple meanings and may be understood by different people in different ways. Therefore, to ensure the content validity of the scale, a careful consideration was required in the choice of words.

The challenge of choosing appropriate words also arose from the fact that written or formal Sinhala language is quite different from the spoken form of the language. The advice of the expert panel was to use a semi- formal language format. This way, it was expected to convey the concepts of wellbeing in a simple, well understood written format of the language.

During the pre-test, it was apparent that the terms were easily understood, and therefore we can state that the process of adaptation, where the choice of the words was considered with careful discussion and analysis, yielded positive results.

It can be concluded that the Sinhala adaptation of the PERMA profiler is well suited to be used in the Sinhala speaking population. The scale is well suited to be used with individuals with average literacy levels. In the case of non-literate population of Sinhala speakers, this may be interview-administered. The semi-formal language format used in the translation would be appropriate for interview-administering the tool.

Ethics Statement

The current adaptation study received Ethical clearance from the Ethics Review Committee (ERC) of the faculty of medical sciences of the University of Sri Jayewardenepura.

Source(s) of support

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Conflict of interests

There are no conflicts of interest

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INTEGRATING SOCIO CULTURAL THEORY AND BLOOM'S TAXONOMY TO OVERCOME XENOGLOSSOPHOBIA AND ANXIETY IN ENGLISH LANGUAGE SPEAKING IN SRI LANKAN UNDERGRADUATES

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ABSTRACT

The importance of knowing a second or a foreign language today has become a pivotal factor with regard to education, travel, trade, business, information, communication and most importantly to acquire a recognizable occupation. Even so, obtaining a job related to a graduate's educational background in the Sri Lankan context at present, is a challenging task. Having realized this, the local government of Sri Lanka have been taking measures in teaching English at local government schools from Grade 3 onwards since 1950's. Nonetheless, even by the time the Sri Lankan local government school children enter university after engaging in English language learning for over a decade and subsequent to Ordinary and Advanced level examinations, their English-speaking skills stand at a marginal level with traits of xenoglossophbia and anxiety. Thus, the aim of the study is to find out the main factors that influence xenoglossophobia and suggest strategies to overcome them. A sample of 32 Engineering undergraduates from the first year of General Sir John Kotelawala Defence University (KDU) was selected based on purposive sampling technique. The selection process was performed based on an Oral Proficiency Interview (OPI). After having exposed the students to a teaching process for 15 academic weeks, they were re-administered through a post-OPI. The lesson plans were set according to Blooms Taxonomy knowledge-based objectives. Socio-Cultural Theory (SCT) was incorporated when designing the lessons. Data was analyzed via a mixed approach. The findings revealed that the students had increased motivation and confidence to speak English as they were exposed to a gradual process of self-autonomy. Paving way for authentic speaking opportunities via Task Based Activities (TBA) and making students aware of the importance of English language communication for employment purposes from school levels is highly important. Further, teacher, learning environment and material play a considerable role in motivating language learners while self-negativity is a main reason for the majority to possess xenoglossophobia which adversely affects their future employability.

KEYWORDS: *Xenoglossophobia, SCT, English language speaking*

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1. INTRODUCTION

English is considered a global language at present, and it is the key to knowledge, information, travel, trade business and technology (Turmapang, 2012). People learn it as a second or a foreign language at present, identifying its benefits and usage. Thus, people have developed intrinsic motivation in improving not only writing and reading skills but also their speaking and listening skills in the English language (Pushpananda, 2016). Recognizing the importance of the language, the local government of Sri Lanka, made it a point to teach English from Grade 3 onwards at local government schools (Perera, 2010). Even though the students learn English for a decade starting from Grade 3 and till G.C.E A/Ls (General Certificate of Education in Advanced Level), they possess traits of anxiety (Gorden, Kuruppu and Kuruppu, 2015). This leads to xenoglossophobia (the fear of speaking a second or a foreign language) with regard to English language speaking at undergraduate level, when compared to the other skills. It has been observed by the researcher during her university teaching career, spanning over a decade, that lack of motivation in participating in class discussions, not taking part in English related activities, deviating from the lessons and the teacher are few of the aspects which display xenoglossophobia in the undergraduates. This ultimately results in producing a graduate output who is incompetent and anxiety-driven when it comes to obtaining a suitable employment prospect in the present-day job market which is highly competitive and largely focused on English language competence (Ranasinghe, 2012).

Considering this situation as the problem, the study aims at exploring the main factors that influence xenoglossophobia in Sri Lankan undergraduates and suggest strategies to overcome them.

2. LITERATURE REVIEW

'Xenoglossophobia' is recognized as the scientific term used for Foreign Language Anxiety (FLA) and is described as a feeling of unease, worry, nervousness and apprehension experienced in learning or using a second or a foreign language (Macmillandictionary.com, 2022; Urbandictionary.com, 2022). There are various reasons causing xenoglossophobia in learners and how to overcome them as stated in literature. According to De Souza (2012), one of the main reasons for the xenoglossophobia in Sri Lankan undergraduates is the monoglot ideology where they disregard English, resulting from the effects of British colonization during when linguistic abuse was experienced by Sri Lankans by not being able to use their mother tongue. Apart from this, the unsuccessful methods used in teaching a second or a foreign language is recognized as a reason for xenoglossophobia by Shiffman (2006). Accordingly, using age-old techniques in teaching such as the grammar translation method, results in lack of motivation in the learners. Shiffman (2006) further describes that by pumping a large amount or grammar and vocabulary into a learner's memory does not bring satisfactory results at the end. Apart from this, the three domains; teacher, material and the environment are inter-connected and work together in developing the language competence of a student (Dislen et al., 2013; Ranasinghe and Leisher, 2009). Accordingly, when the English language teacher is unable to arouse the motivation in learners via diverse lessons, when they are not apt and skillful in delivering the lessons based on students' requirements and when the classrooms are not equipped with the modern technology and creativity, students tend to increase anxiety in speaking. In addition, having mixed ability groups in the classroom also creates negative emotions in the weak students, paving way for higher levels of shyness, embarrassment (Perera (2010). Enguita, Martinez and Gómez (2010) suggest that lack of awareness on the benefits of learning English is a key reason why students lack competence to communicate in the English language. It should be considered as a responsibility of the school teachers to enlighten about the benefits of learning English from school level while providing ample opportunities to communicate in English via various techniques (Hettiarachchi, 2015). This may include communicative task-based, student-centered activities which are enjoyable for students to follow, without making them feel more anxious and nervous in the classroom (Wijetunge, 2016).

Nevertheless, as Meshkat and Hassani (2011) state, one of the main reasons for speaking anxiety is the competitive nature of the examination systems and focusing mostly on covering syllabuses focused on reading and writing by both students and teachers. In the Sri Lankan education system, this is considered as a more important aspect than acknowledging students about the benefit of learning English language in the long run thus, leaving the students inept and incompetent to speak the language.

The lessons designed in this study focus on assisting English as a Second Language (ESL) speakers to overcome xenoglossophobia and thus are based on the knowledge-based objectives of Bloom's Taxonomy while integrating Socio Cultural Theory (SCT). The main and the specific objectives of the lesson plans in the current research are based on the revised Bloom's Taxonomy by Anderson and Krathwohl (2001) focusing on enhancing the English speaking confidence of the students. The lessons at the bottom two tiers of the 6 tiered taxonomy deal with activities which focus on group work, the mid two tiers on pair work and the top two tiers on individual tasks, focused at creating autonomous speakers. This allows the students to gradually come forward and improve their skills rather than fearing or shying away from the tasks.

This is similar to what Vygotsky (1978) stated as SCT. Accordingly, a child's language development takes place in two ways. First, through the social plane where he/ she socializes with the society and acquires the language. Then, through intra-psychological category where he internalizes the language on his own and uses it as an autonomous speaker.

Accordingly, social interaction plays a primary role in enhancing cognition. As mentioned above, after the basic/necessary foundation is laid at the first level through social interaction where the learner acts collaboratively, grasps the knowledge and understanding to move to the next level via group and pair work, he/she is capable of acting independently and autonomously later. As a result, the learner becomes more focused with "voluntary attention logical memory, and formation of concepts. All the higher functions originate as actual relationships between individuals" (Vygotsky, 1978, p.57). The lessons are designed to achieve this particular goal. In addition, Aimin (2013) states, learners thus are responsible for their own learning environment and the environment continues to nurture and scaffold them further. Therefore, the teachers are considered as the active constructors of this learning environment that encourages the learners to be motivated. Therefore, "as a result of the guidance, a novice becomes the effective member of a community" (Behroozizad, Nambiar and Amir, 2014, p.219). With this appropriate instruction and interaction, successful learning occurs as the control between the activities is shifted from the social to the individual plane (Ellis and Barkhuizen, 2005). This stage of ameliorating the cognition of a learner from average to advanced level through assistance is defined as Zone of Proximal Development (ZPD) by Vygotzky under SCT.

In line with SCT, all lessons are mainly based on Task-Based Activities (TBA) and contain pre-, during- and post-tasks (Ellis, 2017). "Using TBAs has proven to improve motivation and confidence in students" (Wijetunge, 2016, p.206). Accordingly, incorporating task variety, authentic and entertaining tasks and providing opportunities for students to learn as a team while focusing on student-centered learning, assists in overcoming classroom anxiety

3. METHODOLOGY

A sample of 32 Engineering undergraduates in the first year of General Sir John Kotelawala Defence University (KDU) was chosen as the sample based on purposive sampling technique. They were exposed to a specific English-speaking programme based on the Socio-Cultural Theory by Vygotsky (1978) and Bloom's Taxonomy Knowledge based Objectives for a period of 15 weeks (1 academic semester, 45 lecture hours). Participant observations were carried out and interviews were conducted for the individual participants and teachers where they were administered through open-ended and close-ended questions. The quantitative data were analyzed using SPSS while the qualitative data were recorded, transcribed, and analyzed using content analysis incorporating Atlas ti using the 6 phases of thematic analysis by Braun and Clarke (2006).

4. ANALYSIS

Based on the responses of the students, the following observations were made on the first and the last day of the programme.

Table1: The general observations made on the first and the last day were as follows.

First day	Last Day
The majority was nervous, less talkative, hesitant to volunteer. Did not answer nor engage in discussions.	The majority was motivated and confident to communicate and respond to questions.
Preferred working in groups. Only the 'best 'speakers volunteered to take part.	Chances were delegated. There were regular speakers in table topics sessions. Students Preferred autonomous activities.
Did not enjoy CTBA: Did not take part, did not take up responsibilities nor engaged in discussions.	Enjoyed CTBA and teamwork, volunteered as leaders and engaged in discussions.
Feared stage performance, were highly reluctant to use the microphones.	Confident on Stage and moved, there were no objections towards using the mikes.
Did not know how to use body language; No facial expressions, no eye contact and looked away when speaking, hands were often in the pockets, clutched, folded or swinging, the use of the stage was nil.	Body language improved. Effective facial expressions, hand and eye coordination and stage movement.
Did not prefer constructive criticism by the peers and felt embarrassed by the teacher feedback.	Valued constructive criticism by peers, teachers and Toastmasters. Responded positively. Used criticism to improve their communication.
Feared to discuss with the lecturers and did not volunteer in the classrooms when questions were asked. Did not involve much in discussions. Unwilling to attend the class.	Became friendly and comfortable with the lecturers over time. Asked for clarifications and made discussions. Even informed when unable to attend the class. Had questions after the sessions.
Nervous around TMs and English speakers, hesitated to present in front of the TMs.	Preferred company of English speakers and performers, wanted to be a part of TMs.
Poor language and insufficient vocabulary	Improved language and vocabulary
Were hesitant to come up as a leader. Did not want to take up the challenges until nominated.	Voluntarily took up leadership roles and were motivated to select leaders for the forthcoming sessions. Came up with interesting topics and words for the day. Requested for assistance when required.

Semi-structured interviews were held with the sample and teachers involved. It was necessary to find out the opinions of the sample towards the teaching-learning process on Communicative Task-Based Activities (CTBA), their attitude towards the change in confidence, motivation and xenoglossophobia levels and suggestions. The opinions of the teachers were also gathered with regard to the reasons for xenoglossophobia in learners and their interaction during the classroom when being engaged in CTBA.

Based on the responses of the students and teachers, the following was derived subsequent to the coding process as the most influencing factors causing xenoglossophobia and classroom anxiety in the learners.

- Impact of socio-economic background and parents' education on the English speaking ability of the sample.
- Teacher, learning environment and material
- Negative experiences during school times
- Unawareness of the benefits of learning English
- Lack of exposure to the language

- Diverse reasons causing phobia
  - Vocabulary
  - pronunciation
  - grammar
  - accent
  - feeling of other being better
  - feeling of being laughed at
  - lack of motivation and confidence to communicate
  - the feeling of being humiliated in front of the other for the negative criticism offered by teachers
  - the fear of being punished for mistakes
  - being inferior in front of the opposite sex

100% claimed that the uncomfortable feeling that they felt on the very first day, disappeared gradually when they participated in the programme. After the programme, it was stated that they could easily engage in day-to-day conversations with outsiders and 80% stated that they had no problem conducting impromptu speeches to unknown audiences. 100% were comfortable in conducting prepared speeches. Many claimed that "I don't care about the mistakes anymore. Even if I make mistakes, I do not care. I am not afraid that others would laugh at me. I have the confidence to say what I have to say".

Marks obtained by the students were clustered according to the UGC marking criterion. Accordingly, it was visible that all students had scored below 45 marks at the pre-test while all had scored above 50% marks at the post test. To witness the statistical significance SPSS was used.

Table 2: **Paired sample statistics Paired sample correlations**

	Mean	N	Std. Deviation	Std. Error Mean
Pair 1 Pre-test OPI	37.50	32	9.639	1.704
Post-test OPI	67.88	32	9.033	1.597

Table 3: **Paired sample statistics Paired sample correlations**

	N 32	Correlation	Sig
Pair 1 Pre and Post-test marks	32	.673	.000

It is revealed that the mean value is higher in the post-test when compared to the pre-test and that the standard deviation in the post-test stands at 9.033, which is a difference of .606. The significant difference of Paired sample correlations is .000.

Table 4: **Paired sample T test on OPI marks**

	Paired Diff				
	Mean	**Std. Devi**	**95% Conf Lower Upper**	**Std. Error Mean**	**Sig. (2-tailed)**
Pair 1 Post-marks Pre-marks	30.375	7.568	27.646 33.104	1.338	.000

A mean value of 30.375 can be witnessed in the paired sample T-test. Standard deviation is 7.568 and the 95% confidence interval of the difference is 5.458. The significant 2-tail stands at .000, below the value 58 of .05 ($p < .05$ 59 making it be a significant difference.

4. RESULTS AND DISCUSSION

It was identified that there were several main reasons for undergraduates to be anxiety-driven with regard to English language speaking. One of the main reasons for this is the exam-oriented nature of the local education system where recognition is provided by teachers solely on preparing the students to excel in the two most competitive examinations in Sri Lanka namely; G.C.E O/L (General Certificate of Education in Ordinary Level) and G.C.E A/L (General Certificate of Education in Advanced Level) and the sole effort of the students is to excel in these two

highly competitive examinations. As a result, even at the home-front, the parents influence the students to focus on passing the written papers (tests only reading and writing) which will ultimately be the only proof of language competence in gaining a suitable employment. The majority of the students do not allocate sufficient time or seek opportunities to engage in improving speaking and listening skills. However, it was identified that based on the socio-economic background of the students, their motivation factors vary.

The teacher, learning material and the environment have a high impact with regard to learner motivation as indicated by Dislen et al., (2013) and Ranasinghe and Leisher, (2009). When the teachers are equally motivated in teaching, using entertaining and innovative methods to teach, building a close rapport with the students and incorporating a variety of activities by creating a stress-free learning environment in the classroom, it leads to better results. Teacher favoritism and punishments on the contrary result in less motivation and involvement. The negative memories associated with school times, where they were mocked and criticized for their mistakes in front of the peers have also resulted in xenoglossophobia and anxiety in English language learning.

Considering about the mechanisms to improve confidence and motivation in students, lesson plans set according to the six tiers of the Bloom's taxonomy, are highly effective in enhancing the students' autonomous learning and speaking skills. Exposing the students to impromptu and autonomous speaking, using a gradual technique assists them to overcome the negative thoughts, anxiety and xenoglossophobia levels. As stated in literature, when students are exposed to be involved in interaction with more skilled peers or individuals, they actively learn more (as cited in Notes, 2018). Learning enhances through social interaction and culture.

Using TBAs while providing opportunities for student-centred learning also assist in improving the confidence to speak in English language. Incorporating the three phases of TBAs as stated by Ellis (2017) encourages the learners to engage and learn and interact actively while enjoying the tasks. Thus, entertaining TBAs including the three phases with diverse activities is recognized as an effective technique to improve motivation and reduce xenoglossophobia.

5. CONCLUSION AND RECOMMENDATIONS

In conclusion, it can be stated that the main reason for xenoglossophobia in Sri Lanka is the exam-oriented education system of the country where insufficient opportunities are provided to the students at school level to improve their speaking skills. Non-recognition of the benefits of learning to aptly communicate in the English language hinders opportunities for undergraduates to obtain a suitable job. Teachers have a huge responsibility to play in this regard.

The recommendations can be stated in tri-fold. First, the government of Sri Lanka should invest sufficient funds to improve English language skills of all teachers and learners of the country despite the socio-cultural, socio-economic obstacles. Secondly, the educational implementing units should allocate trained teachers to teach in all parts of the country and right incentives should be provided to teachers and learners for their hard work. In addition to this, the local syllabuses should be changed regularly while focusing on the needs of students. Thirdly, it is recommended for the teachers to provide awareness to the learners on the benefits of English speaking from school levels. Exposing the students to more speaking opportunities in the classroom, creating a student-centred learning environment with better opportunities to socialize, engaging students more in group activities in order to mingle them with colleagues and build connections, will pave way for the learners to improve motivation and overcome xenoglossophobia. Incorporating TBA based on Bloom's Taxonomy knowledge-based objectives, while giving special recognition to speaking in English, is recommended as a strategy to improve speaking motivation and confidence in students.

Intrinsic motivation to study English language should be inculcated into the minds of all Sri Lankan students. The employment benefits and opportunities available

for a language proficient graduate should be instilled in the students at a young age.

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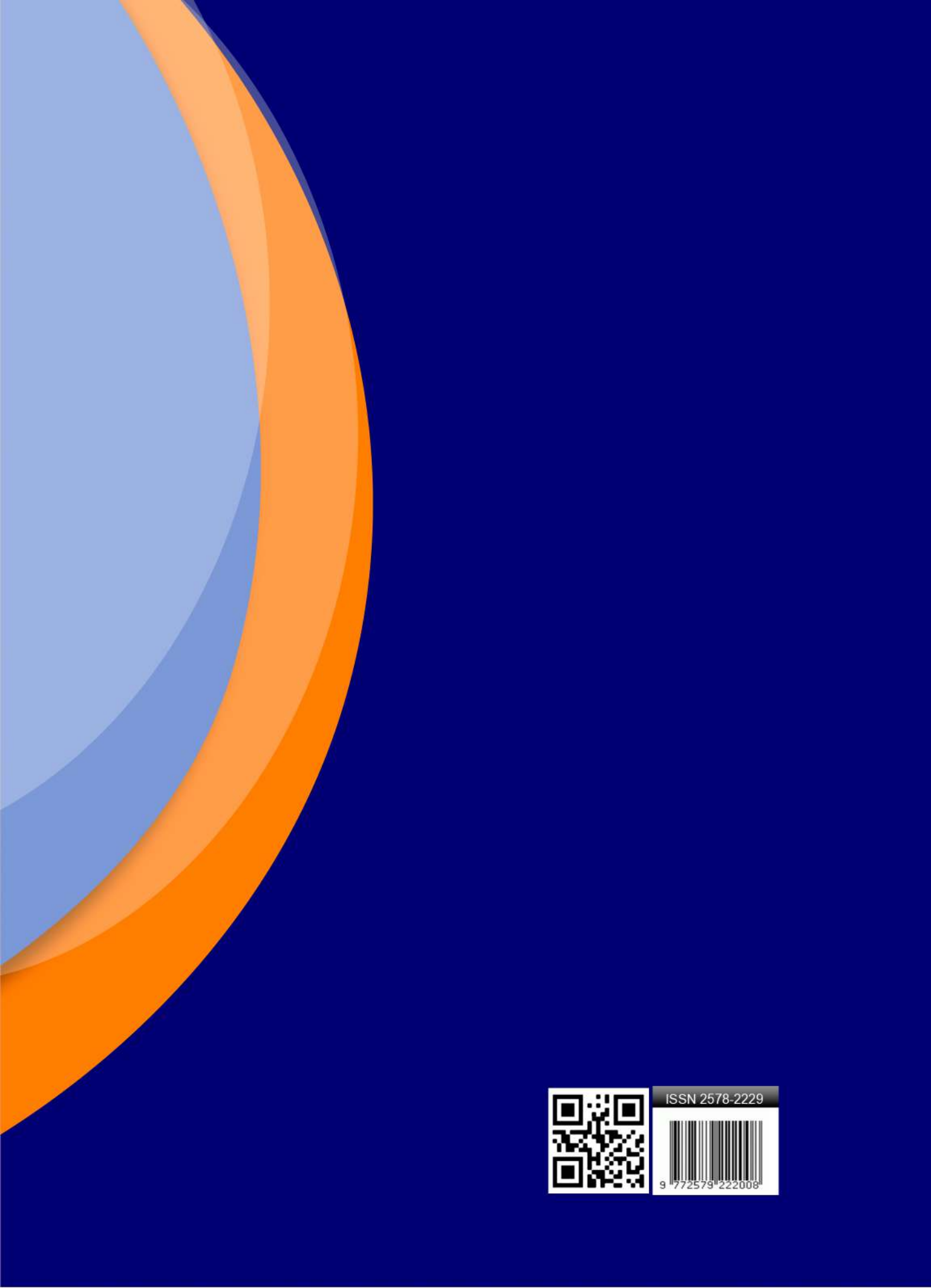
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