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Editorial

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THE IMPACT OF TRAINING AND DEVELOPMENT ON OPERATIONAL LEVEL EMPLOYEES' PERFORMANCE IN THE APPAREL SECTOR, KATUNAYAKE BOI EXPORT PROCESSING ZONE, SRI LANKA

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ABSTRACT

Although there are many more research works on the relationship between Training and Development and workforce development in various industries, little research can be found that elaborates on how training and development can improve the employees working at the operational level within the apparel sector in Sri Lanka, especially within the Katunayake BOI Export Processing Zone, which is a major industrial zone for many leading apparel firms contributing heavily to the economy of Sri Lanka. The study analyzes the impact of Training and Development consisting of Orientation Training, Coaching, and Job Rotation incorporated under Kirkpatrick's Four-Level Evaluation Model. Though commonly used within the industry, the effectiveness of these training methods is still questionable due to the lack of a structured evaluation system, irrelevance of the training to on-the-job requirements, and other persisting issues such as the high turnover rate and the constantly changing technology. Hence this research attempts to fill this gap. From a total population of 465 operational-level employees working in two major apparel factories situated inside the Katunayake BOI Export Processing Zone, 279 respondents were selected through simple random sampling method. The Data was gathered using structured questionnaires analyzed through IBM SPSS 23 version using descriptive statistics, correlation, and multiple regression analysis. It was necessary to get to these findings because of coaching and job rotation, considered statistically significant variables, affecting operational-level employee performance. Orientation training did not prove statistically significant in the model of regression. Human Resource professionals and policymakers should, therefore, ensure that training activities are conducted in line with actual job demands and implement a structured evaluation system to measure the effectiveness of the training and to safeguard continuous improvements in productive performance.

Keywords: *Training and Development, Employee Performance, Operational-level Employees, Apparel Sector, Katunayake BOI Export Processing Zone*

1. Introduction

According to the Central Bank of Sri Lanka (2023), the apparel industry is an important part of Sri Lanka's economy, making up a large share of the country's exports and providing jobs for over 300,000 people. Training and Development is necessary to enhance performance by employees especially when it comes to labor-intensive sectors like the apparel industries. According to There have been numerous studies describing the impact of Development and Training on workforce development in various fields(Kavirathne, Kuruppu, & Karunarathna, 2021). According to Abdirahman (2016), Achi (2016), and Joe (2017), yet few research has been conducted regarding how Training and Development affect operational-level employee performance in the Sri Lankan Apparel sector. This study addresses that gap by focusing on the hosts major apparel export zone Katunayake where many employees are employed, making it an ideal setting for this research (Mulwa, 2024).

As the evaluation processes are unorganized and the training material does not match the demands of the position, the anticipated improvement in performance is seldom achieved (Embuldeniya, 2015). In addition, the persistent challenges in maintaining workforce efficiency and productivity caused by high employee turnover, a shortage of skills, and the advancement of production technologies are problematic. This leads to a wide gap that exists between training provided and the performance appraisal outcomes, thus raising concerns about the effectiveness of such investments (Opatha, 2012). As a result, despite consistent application of these Training and Development strategies, operational-level employees may not demonstrate significant performance gains, making it a critical issue that needs empirical investigation (Mulwa, 2024). Accordingly, the research problem is to address; how Training and Development (Orientation Training, Coaching, and Job Rotation) impact on operational level employees' Performance in the Apparel sector in the Katunayake BOI Export Processing Zone, Sri Lanka?

More specifically, this research has four objectives;

i. To identify the impact of Coaching on operational level employees in the apparel Sector.
ii. To identify the impact of Orientation Training on operational level employees in the apparel Sector.
iii. To determine the impact of Job Rotation on operational level employees in the apparel Sector.
iv. To determine the impact of Training and Development on operational level employees in the apparel Sector.

According to the Kirkpatrick's Four-Level Training Evaluation Model (1994**),** Orientation Training, Coaching, and Job Rotation under training and development were extracted. This model offers a structured approach by evaluating four key levels: Reaction, Learning, Behavior, and Results, which can be applied to evaluate the impact of Orientation Training, Coaching, and Job Rotation on employees' performance. Employee performance is influenced by various factors, including leadership, motivation, working environment, team spirit, training, trust, and organizational commitment, resulting in overall productivity and success (Joe, 2017). Training is an act of leveraging employee's knowledge and skills for performing a specific job (Joe, 2017). Coaching is an unstipulated development assignment that helps

employees achieve personal and organizational goals, increase performance, productivity, job satisfaction, and self-esteem, and reduce workplace problems and stress (Gammanpila, 2020). Orientation training plays a vital role in familiarizing new employees with the organization and raising their general job competence (Gammanpila, 2020). On the other hand, job rotation subject's employees to new roles, improves capabilities, reduces boredom, prevents burnout, and increases their knowledge of business processes as well as improving job satisfaction, motivation, and effectiveness (Abdirahman, 2016). Based on the literature review, the following conceptual framework is developed.

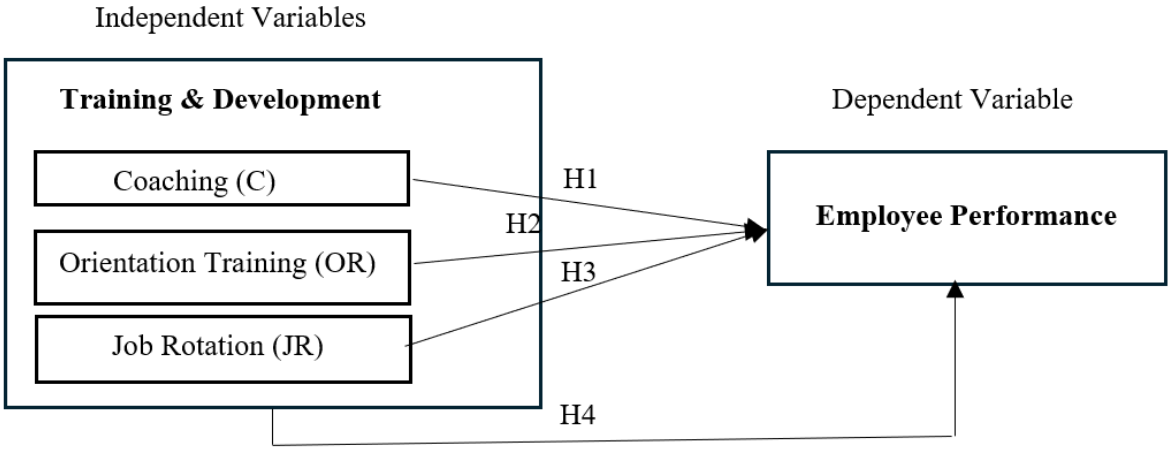

Figure 1: Conceptual Framework

Source: Kirkpatrick, 1994

Based on the conceptual framework, four hypotheses are developed.

H1: There is a significant impact of Coaching on operational level employees' performance.

H2: There is a significant impact of Orientation Training on operational level employees' performance.

H3: There is a significant impact of Job Rotation on operational level employees' performance.

H4: There is a significant impact of Training and Development on operational level employees' performance.

2. Methodology

This study used a quantitative, deductive approach and descriptive analysis. The study focused on operational level employees from the top two apparel companies in Katunayake BOI Export Processing Zone, Sri Lanka. A large proportion of the operational workforce working in these companies constitutes a significant portion of the total population of operational staff in the garment industry. According to Cribbie and Kim (2018) and Sorensen (2002), demographic characteristics such as age, education level, and years of experience were considered to ensure comparability of employees across companies, supporting the assumption of a homogeneous operational-level population and justifying the use of simple random sampling. Accordingly, the population comprised 465 operational-level employees (Company A: 280; Company B: 185). According to Krejcie and Morgan's (1970) sample size table, a minimum of 279 respondents was required. The sample was distributed as 168 employees from Company A and 111 from Company B, selected through simple random

sampling (COCHRAN, 1977). The study used both primary and secondary data. Primary data were collected via a structured 5-point Likert questionnaire, and secondary data from Board of Investment (BOI) records. Data were analyzed using SPSS, including descriptive statistics, correlation, and regression, while Cronbach's Alpha and factor analysis ensured reliability and validity.

3. Results and Discussions

The demographic profile of 279 respondents indicated a mostly experienced and skilled workforce (53.4% female; 66% aged 26–45; 40.9% with A/L or higher; 47.7% with over six years' experience). Descriptive statistics showed high average scores across variables; Employee Performance (M = 4.09), Coaching (3.97), Job Rotation (3.74), Orientation Training (3.55) with low standard deviations (0.516–0.689), strong reliability ($\alpha > 0.83$), and significant positive correlations, strongest for Coaching ($r = 0.661$) and weakest for Orientation Training ($r = 0.383$).

The regression model shows a significant impact on the predictors and employee performance, explaining 51 percent of the variance ($R^2 = 0.510$). The ANOVA indicates that the model is statistically significant ($F = 95.340$, $p < 0.001$), confirming that Coaching, Orientation Training, and Job Rotation collectively predict operational-level employee performance.

Table 1: Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.714	0.510	0.504	0.382

Source: Survey data, 2025

Table 2: Anova

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	41.719	3	13.906	95.340	.000
	Residual	40.111	275	.146		
	Total	81.830	278			

a. Dependent Variable: Performance

Source: Survey data, 2025

Hypothesis testing revealed that Coaching and Job Rotation have a significant an impact on operational-level employee performance, as their significance values are well below the 0.05 threshold. In contrast, Orientation Training does not show a significant effect, as its significance value exceeds the 0.05 threshold. Although individual contributions vary, the overall Training and Development model significantly predicts operational-level employee performance, as confirmed by the ANOVA, explaining over 50 percent of the variance.

4. Conclusions

The study examined the impact of Training and Development specifically Coaching, Orientation, and Job Rotation on operational-level employees in Sri Lanka's Katunayake Export Processing Zone. Results showed Coaching and Job Rotation significantly impacted performance improvement, and Orientation had little impact, suggesting onboarding may be

insufficient. Because the apparel sector is labor-intensive, companies must adopt personal, ongoing development strategies. The study recommends continuous training evaluation. While limited to two factories, the findings have broader relevance and suggest the importance of examining determinants like leadership and organizational culture for a more comprehensive theory of performance.

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IMPACT OF SERVICE QUALITY ON CUSTOMER SATISFACTION IN VEHICLE SERVICE CENTERS IN NEGOMBO

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ABSTRACT

This study discusses the influence of service quality dimensions on customer satisfaction in the car after-sales service industry in Negombo, Sri Lanka a region with relatively underdeveloped automobile service facilities. As customer retention becomes more important in competitive markets, this research employs the model to discuss five main dimensions: Tangibility, Reliability, Responsiveness, Assurance, and Empathy. A quantitative approach was employed, in which a structured questionnaire was administered to 364 car and van service customers. SPSS assisted in analysing data in the form of descriptive statistics, correlation analysis, and multiple linear regression. The findings reveal that Tangibility, Assurance and Empathy significantly and positively influence customer satisfaction. However, Responsiveness reflects a statistically significant, though negative, effect perhaps because of customer displeasure regarding timeliness or follow-up arrangements. The Reliability impact is not significant. The model accounts for a high percentage of customer satisfaction variance with strong explanatory power. This research is limited by the cross-sectional design, single-city coverage, and vehicle type focus. Urban–rural service environment comparisons and longitudinal effects could be explored through future research in order to develop more comprehensive recommendations for Sri Lanka's automobile industry. Service centers should emphasize developing visible quality signals, invest in staff soft skills training, and install real-time service monitoring to become more responsive. Managers should also install real-time feedback systems and Standard Operating Procedures (SOPs) to ensure consistency and accountability. Closing these gaps can not only increase satisfaction but also deepen loyalty in a low-tech, competitive automobile service environment such as Negombo.

Keywords: *Service Quality, Customer Satisfaction, SERVQUAL, Vehicle Services, Negombo*

1. Introduction

1.1 Problem Statement

Even though Sri Lanka has experienced the fastest rise in vehicle ownership, various service centers, especially those located in secondary cities like Negombo, do not attain consistent service quality due to outdated practices, lower customer interaction, and poor infrastructure. This has led to growing customer dissatisfaction and uneven service delivery, and hence it is crucial to explore which aspects of service quality impact the highest level of satisfaction in this sector (Mudiyanselage, 2023).

1.2 Research Objectives

- Primary Objective - Determine the most critical service quality dimensions (reliability, responsiveness, assurance, empathy, and tangibles) that are responsible for customer satisfaction.
- Secondary Objective - Examine the general impact of service quality on customer satisfaction in Negombo vehicle service centres.

1.3 Scope of the Study

Table 1: Scope of the Study

Limitations	**Descriptions**
Geographical Boundaries	The study is confined to Negombo, and therefore results may not entirely reflect service centres in other towns in Sri Lanka.
Sample Size Constraints	The study is restricted to 364 respondents, and this may not encompass all the variations in customer experiences from the different service centres.
Customer Perception Bias	Survey replies are based on personal perceptions, which may be influenced by individual expectations and recent experience.
Industry-Specific Focus	Implications are valid for motor vehicle repair shops but are not automatically directly applicable in other service contexts.
Time Constraints	The study is conducted during a limited period, limiting long-term patterns of customer satisfaction over time.
Limited Secondary Data	There are no pre-existing Sri Lanka-focused studies relating to vehicle service quality, which means there must be reliance upon international literature in terms of theory bases.

Source: Author

2. Literature Review

Service quality has been used globally as the most important determinant of customer satisfaction across different industries. Major service dimensions such as tangibility, responsiveness, and empathy (Parasuraman, 1988) significantly determine customer satisfaction in the automotive services sector. Previous research has established that clean and well-kept physical facilities and well-informed personnel greatly determine customer attitude (Yoo, 2007). Specifically, responsiveness the speed and effectiveness with which personnel respond to customer needs, directly determines satisfaction, although its effect can vary depending on operational efficiency (Munusamy, 2010). In developing economies, including in Sri Lanka, service delivery performance remains incoherent, especially in secondary centers like Negombo. According to Ranasinghe (2020), inadequate technological infrastructure and antiquated procedures make customer satisfaction in local service outlets challenging. The vehicle service industry has received scant attention, despite the fact that it has come to the forefront with the growth in car ownership. This gap in the literature recognizes the need to investigate the effect of service quality dimensions on customer satisfaction in Sri Lankan vehicle service centers, especially in rural areas such as Negombo. This study fills this research gap by exploring the impact of the key service attributes on customer satisfaction in an automobile service environment, with pragmatic implications for improved customer experience in the Sri Lankan setting.

2.1 Theoretical Framework

- Service Performance Model (SERVPERF)
- Expectation-Confirmation Theory (ECT)
- Kano Model of Customer Satisfaction
- Theory of Planned Behaviour (TPB)

2.2 Conceptual Framework

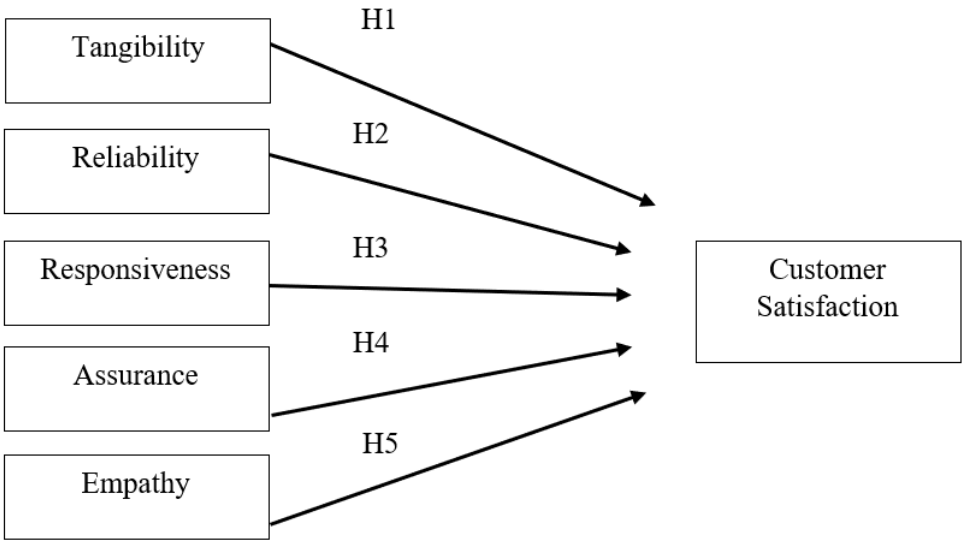

Figure 1: Conceptual Framework

2.3 Hypotheses of the Study

Earlier studies place significance on the dimensions of SERVQUAL as determinants of customer satisfaction in service sectors (Parasuraman, 1988). Responsiveness, reliability, and tangibility influence customers' perception of quality (Yuen & Thai, 2015). Assurance and empathy also facilitate trust and loyalty, particularly in automobile service environments.

H1: There is a tangibility, significant positive impact on customer satisfaction among Negombo motor vehicle service centres.

H2: There is a reliability, significant positive impact on customer satisfaction among Negombo motor vehicle service centres.

H3: There is a responsiveness, significant positive impact on customer satisfaction among the vehicle service centres in Negombo.

H4: There is an assurance, significant positive impact on customer satisfaction among the vehicle service centres in Negombo.

H5: There is an empathy, significant positive impact on customer satisfaction among the vehicle service centres in Negombo.

3.Methodology

Quantitative research design was followed in this research to study the effect of some service quality dimensions on customer satisfaction in Negombo vehicle service centers. A structured questionnaire, which was the primary data collection instrument, was standardized and administered among vehicle user’s car and van owners with recent service experience. 364 were used in the convenience sample; this is more than regression power guidelines (Green, 1991), meets scale satisfactory criteria (Comrey & Lee, 1992), and satisfies item-to-sample ratio guidelines (Hair, 2009), which ensures robust quantitative analyses.

Table 2: Sampling

Criteria	Details
Target Population	Van and car owners in Negombo
Sampling Method	Convenience Sampling
Confidence Level	95%
Ideal Sample Size	364 respondents

Source: Author

The constructs were measured using Likert-scale items based on validated previous research to determine reliability and consistency. The data analysis was done using SPSS through descriptive statistics, correlation analysis, and multiple linear regression. Reliability was checked through Cronbach's Alpha, while normality and multicollinearity diagnostics were done to establish model assumptions.

4. Results and Discussions

4.1 Descriptive Statistics

Table 3: Descriptive Statistics

	Minimum	Maximum	Mean		
	Statistic	**Statistic**	**Statistic**	**Skewness**	**Kurtosis**
Tangibility	1.00	5.00	3.3416	-.519	-.540
Reliability	1.00	5.00	3.2427	-.387	-.611
Responsiveness	1.00	5.00	3.3352	-.556	-.141
Assurance	1.00	5.00	3.3562	-.538	-.309
Empathy	1.00	5.00	3.3636	-.487	-.373
Satisfaction	1.00	5.00	3.3562	-.511	-.333

Source: (Survey Data,2025)

Descriptive statistics showed medium to large mean values on all five scales of service quality (range 3.24 to 3.36 on a 5-point Likert scale), which means customers' overall perceptions towards service quality are positive. Among them, assurance and empathy contained the maximum mean value.

4.2 Frequencies Table

4.2.1 Gender

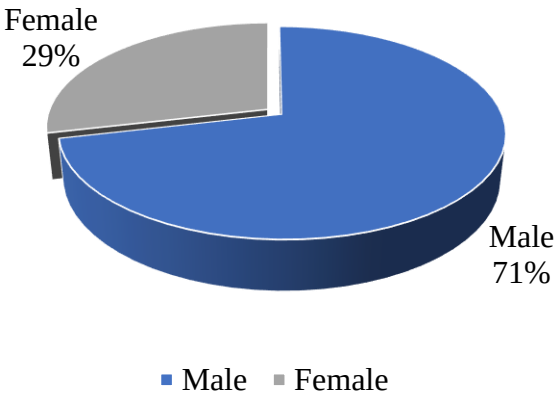

Figure 2: Gender

Source: (Survey Data, 2025)

There were 364 participants in this study. Among them, 260 (71.4%) respondents were men, and 104 (28.6%) respondents were women, a distinct majority of men in the sample.

4.2.2 Age Group

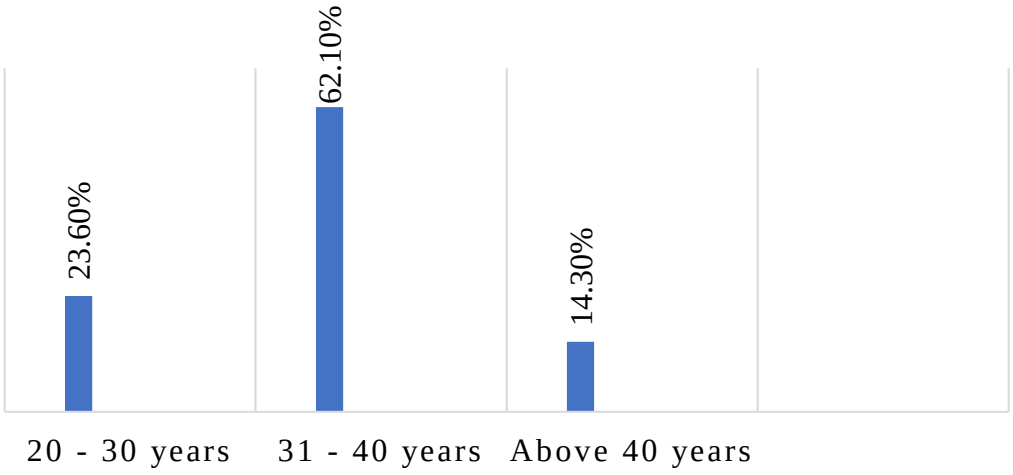

Figure 3: Age Group

Source: (Survey Data,2025)

Out of 364 respondents in this study, 226 respondents (62.1%) were between 31 and 40 years old. This was trailed by 86 respondents (23.6%) between 20 and 30 years old, and 56 respondents (14.3%) over 40 years old.

4.2.3 Types of Vehicles

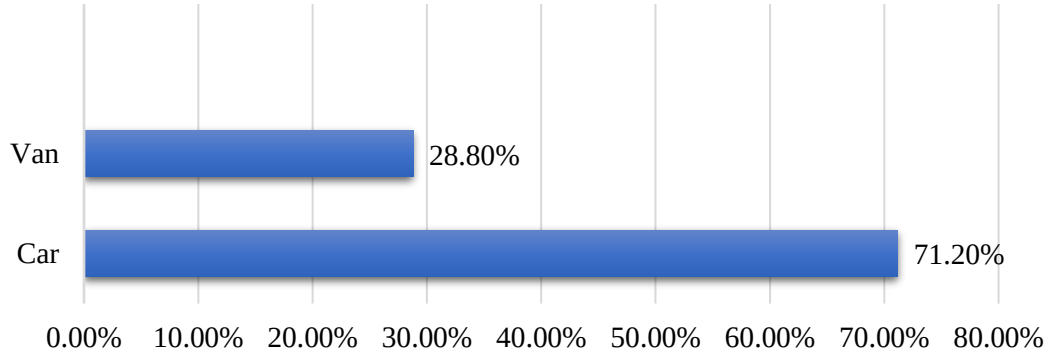

Figure 4: Types of Vehicles

Source: (Survey Data,2025)

Out of 364 respondents, the majority, 259 (71.2%) respondents, indicated that they service cars primarily. Whereas 105 respondents (28.8%) indicated that they service vans primarily. It signifies that car owners form the largest customer group for vehicle service centers in Negombo.

4.2.4 Frequency of Vehicle Servicing

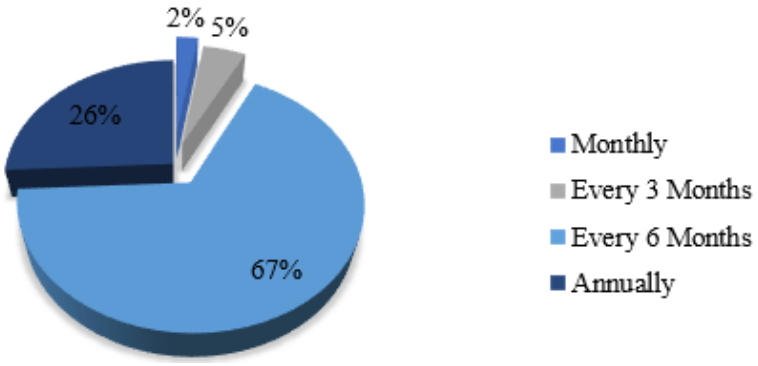

Figure 5: Frequency of Vehicle Servicing

Source: (Survey Data,2025)

Among 364 respondents, 243 respondents (66.8%) stated that they service their cars every 6 months. This was followed by 94 respondents (25.8%) who service their cars once a year, then 18 respondents (4.9%) who service their cars every 3 months, and few respondents, 9 respondents (2.5%), who service their cars monthly.

4.3 Reliability Analysis and Validity Test

Table 4: Reliability Analysis and Validity Test

Variables	Cronbach's Alpha	KMO and Bartlett's Test
Tangibility	0.948	0.775
Reliability	0.931	0.755
Responsiveness	0.952	0.771
Assurance	0.930	0.743
Empathy	0.954	0.772
Customer Satisfaction	0.965	0.781

Source: (Survey Data,2025)

Reliability analysis validated internal consistency of all the constructs, with Cronbach's Alpha coefficients more than 0.93 for all scales, indicating very good reliability. KMO and Bartlett's tests confirmed data adequacy and factorability for all constructs, with KMO values more than 0.74 and significant Bartlett's test statistics ($p < 0.001$), validating the applicability of factor analysis.

4.4 Correlation Analysis

Table 5: Correlation Analysis

Variables	**Pearson Correlation**	**Sig.**	**Positive /Negative**	**Relationship**
Tangibility	.877	.000	Positive	Very Strong
Reliability	.858	.000	Positive	Very Strong
Responsiveness	.860	.000	Positive	Very Strong
Assurance	.895	.000	Positive	Very Strong
Empathy	.882	.000	Positive	Very Strong

Source: (Survey Data, 2025)

Pearson's correlation test confirmed that the five dimensions of service quality are highly and positively related to customer satisfaction among Negombo vehicle service centers. Among them, Assurance was the highest correlation ($r = 0.895$, $p < 0.001$), indicating that professionalism and confidence in staff play a vital role in shaping customer attitudes. This was closely followed by Empathy ($r = 0.882$) and Tangibility ($r = 0.877$), demonstrating that both the care provided personally and the physical environment have profound influences on satisfaction. Similarly, Responsiveness ($r = 0.860$) and Reliability ($r = 0.858$) also registered strong correlations, signifying that customers place a high value on fast response and reliability. All of the correlations were significant at the 0.01 level in support of the conclusion that gains along these dimensions will tend to contribute to more favourable customer satisfaction outcomes.

4.4.1 Multiple Regression Analysis

Table 6: Model Summary

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.919[a]	.844	.842	.39593	1.837

ANOVA[a]

Model		df	Mean Square	F	Sig.
1	Regression	5	60.893	388.451	.000[b]
	Residual	358	.157		

Source: (Survey Data,2025)

The regression equation shows there is a high correlation between customer satisfaction and service quality attributes, with an $R = 0.919$ indicating a very high positive correlation. The R Square is 0.844, which shows that approximately 84.4% variation in customer satisfaction is explained by the combined impact of tangibility, reliability, responsiveness, assurance, and empathy.

Table 7: Regression and Correlation Results Linking SERVQUAL Dimensions to Customer Satisfaction

Predictor	Correlation	β (Std.)	t	p
Tangibility	0.877	.364	7.21	.001
Reliability	0.858	.106	1.84	.067
Responsiveness	0.860	–.157	–2.16	.032
Assurance	0.895	.390	4.59	.001
Empathy	0.882	.250	3.39	.001

Source: (Survey Data,2025)

4.5 Hypothesis Testing Using Regression Coefficients

Table 8: Hypothesis Testing

Source: (Survey Data, 2025)

Hypothesis	Results	B	Sig.
H1: Tangibility positively influence customer satisfaction.	Accepted	0.358	.000
H2: Reliability positively influence customer satisfaction	Rejected	0.105	.067
H3: Responsiveness positively influence customer satisfaction	Rejected	-0.162	.032
H4: Assurance positively influence customer satisfaction	Accepted	0.387	.000
H5: Empathy positively influence customer satisfaction	Accepted	0.254	.001

According to the regression output, the unstandardized coefficient of Tangibility is B = 0.358 with t-value 7.209 and p-value (significance level) of 0.000. Since the p-value is less than 0.05, we reject null hypothesis (H_0) and accept the alternative hypothesis (H_1).

The regression results indicate that the unstandardized Reliability coefficient is B = 0.105 with t-value 1.836 and p-value 0.067. Since the data p-value is higher than 0.05, the outcome is not statistically significant at 5%. Therefore, we cannot reject the null hypothesis (H_0).

According to the regression analysis, Responsiveness has an unstandardized coefficient of -0.162 and a p-value of 0.032, which is statistically significant at the 5% level ($p < 0.05$). Whereas responsiveness was positively correlated with customer satisfaction, the negative regression coefficient indicates that, holding other dimensions of service quality constant, higher responsiveness on its own will not lead to higher satisfaction.

The regression test showed that there was a positive significant relationship between satisfaction and assurance, where the unstandardized coefficient was B = 0.387, the standardized Beta was 0.390, and t-value was 4.590. The p-value of 0.000 shows strong statistical significance at 0.01.

The fifth hypothesis sought to determine whether empathy positively influences customer satisfaction at Negombo vehicle service centres. The regression output revealed an unstandardized coefficient (B) of 0.254 and a standardized beta of 0.250, t-value of 3.387 and p-value of 0.001. Since the p-value is well below the 0.05 level, the outcome is statistically significant, and the null hypothesis is rejected (Caruana, 2002).

5. Conclusions and Recommendations

The research has shown that customers' satisfaction in Negombo vehicle service centers is strongly driven by tangibility, assurance, and empathy. These observations highlight that well-kept facilities, assertive staff, and care tailored to personal needs are key drivers of a high-quality customer experience.

5.1 Exceptions and Limitations to General Findings

Table 9: General Findings

Finding	Description
Negative outcome for Responsiveness	While highly correlated, Responsiveness was negatively regressed, possibly due to interactions with other factors or opposite service behaviour in Negombo.
Reliability not significant	Reliability did not significantly contribute to satisfaction, suggesting that customers may appreciate other aspects such as staff attitude.
Limited generalizability	Results are applicable to Negombo and cannot necessarily be extrapolated to locations with well-developed service infrastructure.
Cross-sectional design	Data were collected at one point in time, excluding estimates of long-term trends in customer satisfaction

Source: Author

5.2 Recommendations

Enhance the service quality, automobile service centers need to spend on infrastructure, neatly maintained customer waiting lounges, well-guided signage, and uniforms for employees, which significantly influence customer opinions. Dependability and reliability can be fostered by adopting standardized operating procedures (SOPs), electronic job cards, computerized service tracking, and warning systems that minimize errors and generate confidence among customers. Responsiveness can be improved through the training of employees, computerized waiting line management software, and in-service observation applications, particularly during rush hours. Service personnel also need to be trained not only in technical skills but also communications skills, as professionalism, courtesy, and frank communication regarding the status of the vehicle help instill confidence in customers. Finally, customer individualization can be enhanced through the usage of CRM software which captures customer histories, preferences, and grievances and fosters empathy through customer service training programs and employee incentives based on high emotional intelligence.

5.3 Direction For Future Research

Follow-up studies should expand the geographic areas beyond Negombo to include diverse locations in Sri Lanka to allow for more generalizable results. Researchers can add other types of vehicles and classes of services, such as motorcycles and commercial fleets, for a comprehensive outlook. A longitudinal design can also facilitate tracking changes in customer satisfaction over time. Future research may also examine moderating variables such as digital service integration, price sensitivity, or brand loyalty to understand more intricate customer behaviours and expectations in the local auto service market.

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IMPACT OF JOB DESIGN ON MANAGERIAL EMPLOYEES' JOB PERFORMANCE IN THE APPAREL SECTOR IN GAMPAHA DISTRICT, SRI LANKA

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ABSTRACT

Job design plays a key role in improving employee performance by enhancing job satisfaction and motivation. Although the apparel industry is vital to Sri Lanka's economy, research on managerial job design remains limited. Managers often face challenges such as unclear roles, heavy workloads, limited autonomy, and poor feedback, which can impact their performance and morale. This study investigates the impact of job design on the performance of managerial employees in Sri Lanka's apparel sector, focusing on the Gampaha District, a significant industrial hub. Guided by the Job Characteristics Model, the research examines five core job design dimensions: Skill Variety, Task Identity, Task Significance, Autonomy, and Feedback. A quantitative approach was used, with a structured questionnaire administered to 169 managerial employees from 302 individuals working in three top apparel companies in the Gampaha District using a simple random sampling technique. Data were analyzed using SPSS, employing descriptive statistics, correlation, and multiple regression techniques. Findings indicate that most job design dimensions, particularly Feedback, have a significant positive impact on managerial job performance. However, Task Identity, while positively correlated, did not exhibit statistical significance in the regression model. This study provides useful insights for HR professionals and industry leaders seeking to enhance managerial productivity through better job design. By emphasizing the significance of feedback, autonomy, and meaningful work, the research offers practical ways to improve job satisfaction, reduce turnover, and create performance-driven work environments in the apparel sector.

Keywords: *Job Design, Job Performance, Managerial employees, Apparel Sector, Gampaha District*

1. Introduction

The apparel industry is an important part of Sri Lanka's economy, making up a large share of the country's exports and providing jobs for over 300,000 people (Board of Investment of Sri Lanka, 2022). Managers in this sector are crucial as they plan, oversee, and make important decisions that help their organizations succeed (Disanayaka & Bandara , 2020). Despite their importance, research on job design and its impact on managerial performance in Sri Lanka's apparel industry remains limited (Zareen et al., 2013). Most existing studies have concentrated on operational-level employees, leaving a gap in understanding managerial roles (Disanayaka & Bandara, 2020). This study addresses that gap by focusing on the Gampaha District, an industrial hub that hosts major apparel export zones such as Biyagama and Katunayake, where a large number of managerial professionals are employed, making it an ideal setting for this research (Board of Investment of Sri Lanka, 2022).

Despite the strategic importance of managerial roles in Sri Lanka's apparel sector, poor job design characterized by limited skill variety, unclear task identity, low task significance, restricted autonomy, and insufficient feedback remains a persistent issue. Such inadequacies in the job design dimensions undermine managers' decision-making quality and overall effectiveness. To address this research gap, the study aims to answer the following research question: "How do Job Design (Skill Variety, Task Identity, Task Significance, Autonomy, and Feedback) impact managerial employees' job performance in the apparel sector in the Gampaha District, Sri Lanka?"

More specifically, this research has five objectives;

i. To investigate the impact of skill variety on managerial employees' job performance in the apparel sector in the Gampaha district, Sri Lanka.
ii. To investigate the impact of task identity on managerial employee job performance in the apparel sector in the Gampaha district, Sri Lanka.
iii. To investigate the impact of task significance on managerial employee job performance in the apparel sector in the Gampaha district, Sri Lanka.
iv. To investigate the impact of autonomy on managerial employee job performance in the apparel sector in the Gampaha district, Sri Lanka.
v. To investigate the impact of feedback on managerial employee job performance in the apparel sector in the Gampaha district, Sri Lanka.

This study aims to examine the job design, outlines five main aspects that can lead to meaningful work and better performance based on the Job Characteristics Model (Hackman & Oldham, 1976). Job performance is an important factor that can be considered whether an organization's employees are doing their jobs properly or not (Mendis, 2016). Job design is the process of specifying the activities of an employee or group in an organization (Moss, 2021). Skill variety refers to the extent to which an employee needs to acquire a range of different abilities, skills, and knowledge to perform a job (Garg & Rastogi, 2006). Task Identity means a job or task that others define and follow procedures others create (Foss et al., 2009). Task significance is the extent to which the job affects the lives and work of other people (Garg & Rastogi, 2006). Autonomy is a matter of whether the job gives the employee the freedom to decide when and how to perform particular tasks (Foss et al., 2009). Feedback is another step that researchers find essential to an employee's motivation, satisfaction, and performance (Foss

et al., 2009). Based on Hackman and Oldham's Job Characteristics Model (1976), the following conceptual framework is developed.

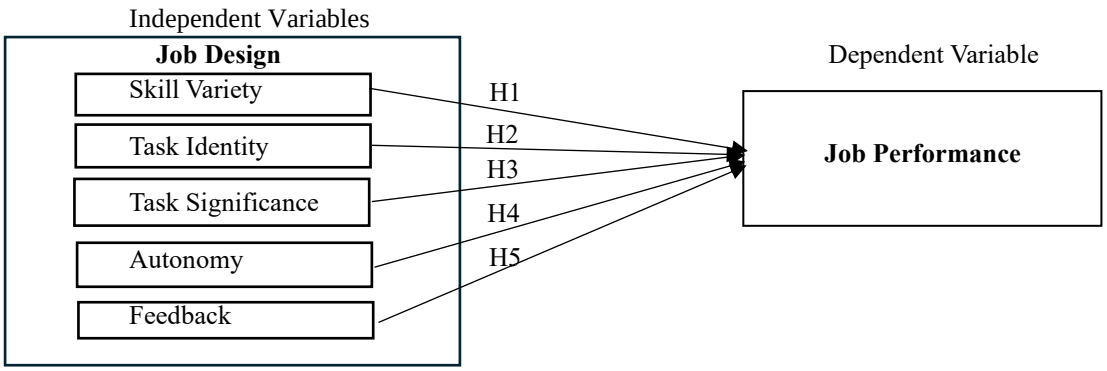

Figure 1: Conceptual Framework

Source: Hackman & Oldham, 1976

Based on the conceptual framework, five hypotheses were developed.

H1: Skill variety has a significant impact on managerial employees' job performance in the apparel sector.

H2: Task identity has a significant impact on managerial employees' job performance in the apparel sector.

H3: Task significance has a significant impact on managerial employees' job performance in the apparel sector.

H4: Autonomy has a significant impact on managerial employees' job performance in the apparel sector.

H5: Feedback has a significant impact on managerial employees' job performance in the apparel sector.

2. Methodology

This study used a quantitative, deductive approach and a cross-sectional design to capture data at a single point in time, with a mono-method strategy ensuring consistency. Descriptive analysis summarized key patterns, and the individual managerial employee served as the unit of analysis. The study focused on managerial employees from the top three apparel companies in the Gampaha District based on the large proportion of the management workforce. For managerial roles, performance was assessed using a perceptual self-report scale rather than operational output, which is recommended for non-production employees (Dodd & Ganster, 1996). To ensure the managerial functions were comparable across companies, demographic characteristics such as age, education level, and years of managerial experience were analyzed, supporting the assumption that the managerial population was homogeneous and justifying the use of simple random sampling across all companies (Kim & Cribbie, 2018); (Sorensen, 2002). According to Krejcie and Morgan's (1970) sample size determination table, a minimum sample of 162 was required from the total population of 302 managerial employees across three apparel companies in Katunayake (A=196, B=68, C=38). According to Cochran (1977) proportional allocation method, the sample was distributed as 106 from Company A, 36 from Company B, and 20 from Company C. The study used both primary and secondary data. The secondary data were collected from the board of investment and websites of the relevant companies. Following a positivist paradigm, primary data were collected through a structured questionnaire, using a

5-point Likert scale. Data analysis were conducted using SPSS, incorporating descriptive statistics, correlation, and multiple regression.

3. Results and Discussions

The respondent profile showed a male majority (54%), mostly aged 41–50 years (40.2%), with majority Master's degrees (45%) and more than five years managerial experience (39.6%). Job Performance recorded the highest mean (M = 4.20), indicating positive perceptions, with low standard deviations showing consistent responses. Reliability was strong ($\alpha > 0.70$) for five variables and acceptable for one ($\alpha = 0.662$). Correlation analysis showed positive and statistically significant relationships ($p < 0.01$) between all job design factors and performance, with Task Significance ($r = 0.576$), Feedback ($r = 0.575$), and Skill Variety ($r = 0.567$) strongest, followed by Task Identity ($r = 0.536$) and Autonomy ($r = 0.506$). These findings suggest that enhancing job design can improve performance.

In regression analysis, ANOVA output shows the model's statistical significance ($F = 35.913$, $p = 0.000$), indicating that job design dimensions collectively impact on performance. The regression result showed that Skill Variety ($P < 0.001$), Task Significance ($P = 0.002$), Feedback ($P < 0.001$), and Autonomy ($p = 0.046$) significantly affect performance, while task identity ($p = 0.124$) does not significantly impact on performance. The model accounted for 52.4% of the variance in job performance ($R^2 = 0.524$) with a strong correlation ($R = 0.724$).

Table 1: Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.724	.524	.510	.323
a. Predictors: (Constant), Feedback, Autonomy, Skill Variety, Task Significance, Task Identity				

Source: Survey data, 2025

Table 2: ANOVA

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	18.750	5	3.750	35.913	.000
	Residual	17.021	163	.104		
	Total	35.771	168			
a. Dependent Variable: Job Performance						
b. Predictors: (Constant), Feedback, Autonomy, Skill Variety, Task Significance, Task Identity						

Source: Survey data, 2025

4. Conclusions

This study confirms that job design significantly influences managerial performance in Sri Lanka's apparel industry. Skill variety, task significance, autonomy, and feedback positively impact performance, with feedback being the most influential, while task identity was not statistically significant. These results support the Job Characteristics Model (JCM), emphasizing the importance of well-structured roles. Organizations can enhance performance

by improving feedback systems, promoting skill development through cross-training and job rotation, increasing autonomy, linking tasks to organizational goals, clarifying responsibilities, and conducting regular job design reviews. Job performance was measured using perceptual self-report scales, and JCM dimensions were assessed using validated instruments adapted for the apparel sector. Such strategies foster a performance-focused culture, improve motivation, and reduce turnover. The study is limited by its focus on managerial staff in a single district, the cross-sectional design, reliance on self-reported data, and a sample drawn from only three companies, which may limit generalizability. Future research should include employees at different levels, adopt qualitative methods, and consider evolving work trends to develop a more comprehensive understanding of job design's impact.

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THE IMPACT OF ON-THE-JOB TRAINING ON EMPLOYEE PERFORMANCE: A STUDY AT SML DUALPLAST LANKA (PVT) LTD, KATANA, SRI LANKA

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ABSTRACT

This study investigates the impact of On-the-Job Training (OJT) on the performance of employees in SML Dualplast Lanka (Pvt) Ltd, Katana, Sri Lanka. With Sri Lanka's rapidly growing manufacturing industry, having effective human capital with systematic training is required for increased productivity and performance of employees. This study aims to investigate the impact of key variables of OJT-job training; namely instructions and coaching on the performance of employees. A sample of 132 employees from SML Dualplast Lanka (Pvt) Ltd, Katana, was selected using the simple random sampling technique. A quantitative method was used to collect empirical data using a standardized questionnaire among employees from various departments. SPSS software 2023 was used to analyze the data in descriptive statistics, Cronbach's Alpha reliability test, Pearson correlation, and multiple regression analysis. Regression analysis revealed that Job Instructions has a statistically insignificant effect on employee performance. In contrast, Coaching showed a significant impact. These findings suggest that Coaching is a more effective On-the-Job Training method for improving employee performance than Job Instructions in the context of SML Dualplast Lanka (Pvt) Ltd. This study contributes to the literature by providing empirical evidence related to the effectiveness of OJT in a Sri Lankan manufacturing environment and offers practical insights for human resource development. It also attempts to identify certain training practices that can be enhanced for better delivery of performance outcomes and recommends a shift in focus towards coaching-based training modules.

Keywords: *On-the-Job Training, Coaching, Job Instructions, Employee Performance, SML Dualplast Lanka (Pvt) Ltd.*

1. Introduction

In the competitive industrial era of today, organizations are perpetually searching for creative means of enhancing employees' performance and making the workforce competent. Employee upgradation and skill development are matters of paramount concern, particularly in industries like manufacturing that are labour-intensive. On-the-Job Training (OJT), offering real hands-on experience in actual work settings, has emerged as a key strategy to enhance the performance of the workforce. Therefore, the present study aims to examine the effectiveness of On-the-Job Training components; job instructions and coaching on employees' performance in SML Dualplast Lanka (Pvt) Ltd, Katana, Sri Lanka.

While extensive literature exists on the impact of On-the-Job Training (OJT) across industries, research specifically focused on the Sri Lankan manufacturing industry, and more precisely on manufacturing sector, remains scarce. Much of the existing research is geared toward the service sector, leaving a gap in understanding the specific productivity effects of training in manufacturing. While global studies have demonstrated the positive relationship between training and job performance, these findings may not fully apply to Sri Lanka due to differences in industrial operations, economic conditions, and workforce characteristics.

However, most companies struggle to implement effective On-the-Job Training (OJT) programs in the manufacturing industry due to a lack of job-specific training content, inconsistent training practices, limited assessment processes, and resource constraints. Additionally, many firms rely on diverse and sometimes outdated training techniques, making it challenging to establish a structured and rigorous workforce development system (Jensen & Schultz, 2014). The second important reason is the lack of systematic evaluation mechanisms to quantify training effectiveness. Since there are no evaluation tools, organizations are unaware if their employees learn and apply the acquired knowledge, and, therefore, they continue to have inefficiencies and high costs of production. In addition, a lack of managerial dedication to constant staff enhancement will lead to disjointed training activity instead of well-drafted long-term schemes (Sabbaghi & Zarei, 2015).

SML Dualplast Lanka (Pvt) Ltd, Katana, Sri Lanka, recruiting only experienced employees who have to work through a system, provides on-the-job training periodically through job instructions and coaching employees due to frequent system updates. However, the company faces challenges in delivering effective training due to a lack of resources and qualified trainers. As a result, employees struggle to adapt to system changes, leading to operational difficulties and job dissatisfaction (SML Group, 2023). Accordingly, this study aims to examine the research problem is; How does the On-the-Job Training (Job Instructions, coaching) significantly impact on employee performance in SML Dualplast Lanka (Pvt) Ltd, Katana, Sri Lanka?

More specifically, this research has five objectives;

I. To examine the impact of job instruction on Employee Performance in SML Dualplast Lanka (Pvt) Ltd, Katana, Sri Lanka.
II. To examine the impact of coaching on Employee Performance in SML Dualplast Lanka (Pvt) Ltd, Katana, Sri Lanka.

With the continuously speeding production pace, On-the-Job Training (OJT) is now a crucial process in enhancing worker performance. Based on the experiential learning theory, OJT allows learning by experience with real implementation on on-the-job work, mixing learning with actual work assignments as closely as possible. Various theoretical models are utilized in this research to examine the roles of job instruction and coaching in OJT. First, Experiential Learning Theory (Kolb, 1984) legitimized active experience and reflection in learning, legitimized work practice activity as an effective pedagogy. Second, Human Capital Theory (Becker, 1964) contend that employee capability investment-training increases productivity and economic return, legitimizes long-term value of work instruction and coaching. Third, the Transfer of Training Theory (Baldwin & Ford, 1988) illustrates how environmental conditions of work and training approach affect application of skills learned in the work setting. All these theories together support the research focus on job instruction (as formal learning by demonstrating the job) and coaching (as special guidance with feedback), locating them as key sub-elements of effective OJT.

On-the-Job Training has been defined by Aguinis as a systematic process through which the workers are provided with an opportunity to gain job-related skills while they work on assigned tasks in the real workplace environments (Aguinis, 2009). Job Instruction has been viewed by Saks and Haccoun as a step-by-learning process where the job tasks are taught and demonstrated by the instructor or supervisor prior to the employee doing these under instruction. Coaching, according to Whitmore, is one-to-one improvement discussions designed to improve performance, build self-awareness, and achieve career objectives. Finally, Campbell categorizes Job Performance into activities and outcomes adding value to organizational objectives, e.g., productivity, efficiency, and work quality.

Conceptual Framework

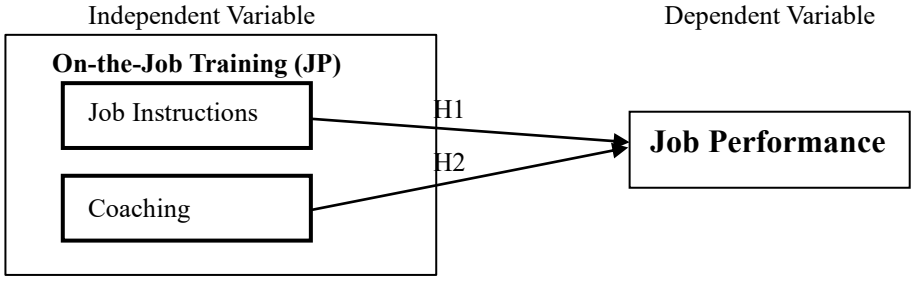

Figure 1: Conceptual Framework

Source: Noe (2010); Aguinis (2009); Armstrong & Taylor (2020)

Based on the Conceptual framework, two hypotheses can be derived;

H1: Job Instructions have a significant effect on the performance of employees.
H2: Coaching has a significant on the performance of employees.

2. Methodology

This research employed a quantitative approach in order to allow statistical analysis of employees' views. A structured questionnaire survey was used to interview 132 workers who were selected with the help of simple random sampling. The instrument employed a five-point Likert scale to capture training effectiveness perceptions and job improvement. Job instructions, coaching were the variables measured. The instrument employed a five-point Likert scale adapted from established training and performance measures to capture training effectiveness and job improvement. Analysis was performed using the help of SPSS software. Construct reliability was confirmed with Cronbach's Alpha, which was over 0.96 for all the variables, indicating high internal consistency. Pearson correlation was used to uncover relationships between the variables, and multiple regression analysis explored predictive strengths of the dimensions of training towards employee performance. It was pilot tested, too, in order to make it more targeted, concise, and readable.

3. Results and Discussions

The descriptive statistics indicated that all key variables; On-the-Job Training (OJT), Job Instructions, Coaching, and Employee Performance recorded relatively high mean values (above 4.0 on a 5-point scale). This suggests that employees generally perceived OJT practices and their performance outcomes positively. Correlation analysis further revealed strong positive relationships between OJT and employee performance, with Coaching showing the highest correlation. Job Instructions also demonstrated a positive, though comparatively weaker, relationship with performance. These results highlight Coaching as the most critical OJT component in enhancing employee performance within the organization.

The regression model demonstrated strong explanatory power, with an R^2 value of 0.809, indicating that over 80% of the variance in employee performance was explained by the OJT dimensions. The ANOVA confirmed that the overall model was statistically significant ($F = 177.42$, $p < 0.001$). In terms of hypotheses testing, Coaching showed a strong and significant positive effect on employee performance ($\beta = 0.456$, $p < 0.001$), supporting H2. Job Instructions also showed a positive relationship but did not reach statistical significance ($\beta = 0.239$, $p = 0.072$), leading to the rejection of H1. These findings highlight Coaching as the most effective OJT component for improving employee performance in the studied context.

Table 1: Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.900	0.809	0.805	0.436

Source: Survey Data, 2025

Table 2: ANOVA Table

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	40.015	3	13.338	177.420	0.000
Residual	10.272	128	0.080		
Total	50.287	131			

Source: Survey Data, 2025

4. Conclusion

This study confirms that On-the-Job Training (OJT) is a significant impact to employees' performance in manufacturing firms. Among On-the-Job Training variables, coaching has the greatest positive impact, followed by experiential learning, with job instructions having a relatively weaker impact. The findings are in accordance with research objectives and validate. The findings call on organizations, especially the manufacturing industry, to spend more on systematic training and on-the-job training experiences and reassess the efficiency of traditional modes of learning. The findings also pinpoint where one would have to carry out additional research to establish the long-term effects of OJT and its application across sectors.

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IMPACT OF JOB-EDUCATION MISMATCH ON SKILL UTILIZATION AMONG WORKFORCE: WITH SPECIAL REFERENCES TO INDUSTRY SECTOR IN CASE OF GAMPAHA DISTRICT IN SRI LANKA

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ABSTRACT

Job-education mismatch is a growing concern globally, yet there remains a notable research gap in the Sri Lankan context, especially regarding how mismatches impact skill utilization among the workforce, especially in the industrial sector. While much attention has been paid to unemployment and underemployment statistics, limited empirical work has examined how overeducation and undereducation affect the actual use of skills in the workplace. Accordingly, this study investigates the impact of job-education mismatch on skill utilization among the industrial workforce in the Gampaha District, Sri Lanka, with a focus on two variables of skill mismatch: overeducation and undereducation based on Job Assignment Theory. A quantitative approach was employed, and based on an estimated population of 700,000 industrial workers in the Gampaha District, 384 workers were selected using random sampling method. A structured questionnaire was used to gather data through both online and in-person. Data were analyzed by regression analysis in SPSS 27 version and descriptive statistics. The findings revealed that both overeducation and undereducation significantly impact skill utilization. Accordingly, there is a significant impact of job-education mismatch on skill utilization among the workforce in the industrial sector in Gampaha District in Sri Lanka. The study emphasizes the importance of aligning educational programs with labor market needs. Employers are encouraged to offer continuous training, while policymakers should focus on curriculum relevance and vocational guidance to minimize mismatch and improve productivity.

Keywords: *Job-education Mismatch, Overeducation, Undereducation, Skill Utilization, Gampaha District*

1. Introduction

In a rapidly evolving global labor market, the alignment between educational qualifications and occupational requirements has become a critical determinant influencing workforce efficiency and socioeconomic development. However, disparities between academic credentials and employment roles often lead to inefficient allocation of human capital. This mismatch occurs in two principal forms i.e., overeducation and undereducation. Both forms contribute to reduced skill utilization and economic inefficiency (Leuven & Oosterbeek, 2011). Gampaha District, a dynamic and industrially heterogeneous region of Sri Lanka, contributes significantly to national employment. Due to its economic vibrancy and industrial concentration, it serves as an ideal empirical setting to explore the implications of education job mismatch.

Despite the growing concern, limited empirical investigations have examined how these mismatches directly affect the skill utilization among the workforce in the Sri Lankan industrial sector. The Annual Labour Force Survey (2009) reports that 3.3% of individuals with A/L qualifications or higher are underemployed, with a higher prevalence among women. These statistics highlight a form of underutilization of human capital, where many educated workforces are employed in roles that do not match their capabilities, leading to skill wastage, reduced productivity, and diminished returns on educational investment. Undereducation is also prevalent, particularly in the industrial sectors, where employees often work in roles demanding qualifications or competencies they do not possess. This results in decreased job performance, skill gaps, and lower organizational efficiency. Similarly, many degree and diploma holders are employed in positions below their qualification thresholds, especially in industrial sectors with limited knowledge intensive occupations. This over-education leads to employee dissatisfaction, low organizational engagement, and misallocation of educational resources (Department of Census and Statistics, 2023). Accordingly, this study seek to address this research gap by examining the Job-Education Mismatch (undereducation and overeducation) impact skill utilization among the workforce in the industrial sector in Gampaha District, Sri Lanka. Based on that the objectives of this research were;

i. To investigate the impact of overeducation on skill utilization among workforce in the industrial sector in Gampaha District in Sri Lanka.
ii. To analyze how undereducation affects the skill utilization among workforce in the industrial sector in Gampaha District in Sri Lanka.

Job Assignment Theory developed by Sattinger (1993), proposes that mismatches between an employee's educational level and job requirements affect skill utilization and productivity. A job–education mismatch occurs when an employee's level of education does not align with the requirements of their job, which can manifest in two forms: overeducation and undereducation (International Labour Organization, 2020). Skill utilization means a person's credentials and experience match their job duties, guaranteeing that their abilities are used productively at work. How well employees use their knowledge, skills, and abilities in their job duties is referred to as skill utilization (Felstead et al., 2012). Accordingly, Skill Utilization means how well employees use their knowledge, skills, and abilities in their job duties is referred. To improve job performance, employee satisfaction, and overall organizational productivity, it is

essential to use skills effectively. Job-education mismatch occurs when workers' educational attainment and the level of education needed for their jobs are inconsistent, it's known as a job-education mismatch (Leuven & Oosterbeek, 2011). Similarly, job-education mismatch is described as a circumstance in which employees' educational attainment is insufficient to meet the requirements of their positions (Allen & Veldon, 2012). Further, job-education mismatch means the difference between a person's level of education and what their employer requires in terms of education. This mismatch can show up as either undereducation or overeducation. Overeducation means a worker possesses more formal education than necessary for their role, leading to underutilization of skills and reduced job satisfaction (Verhaest & Omey, 2009). Undereducation arises when an employee has less education than what is typically required, potentially hindering performance due to inadequate knowledge or skills (Green & Henseke, 2016). Based on this literature review and the Job Assignment Theory, the following conceptual framework was depicted for the study.

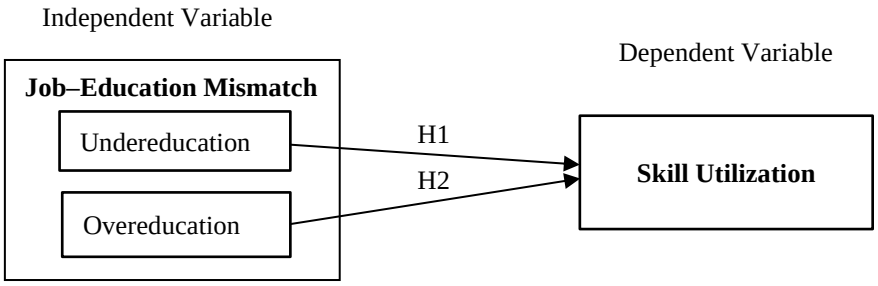

Figure 1: Conceptual Framework

Source: Sattinger, 1993

According to the conceptual framework researcher can draw following hypotheses;
H1: There is a significant impact of Under-Education on Skill Utilization among workforce
H2: There is a significant impact of Over -Education on Skill Utilization among workforce

2. Methodology

For this research, a deductive approach was used where it initiates with a comprehensive review of literature to identify gaps in literature. Quantitative study was used to collect data. The population is 700,000 individuals employed in the industrial sector in Gampaha district. Based on Krejcie and Morgan's sampling table, a sample of 384 respondents was selected using simple random sampling. This sampling technique reduces selection bias and sampling error, enhancing the generalizability of findings to the broader industrial workforce in Gampaha District. Primary data were collected using a structured questionnaire with a five-point Likert scale, distributed both online and in person by randomly selecting industrial companies in the Gampaha District. Secondary data sources included the Central Bank Annual Report 2023 and Census and Statistical Report 2023. Data were analyzed using SPSS.

3. Results and Discussions

Cronbach's Alpha was used, showing excellent internal consistency reliability across all constructs: Job-Education Mismatch ($\alpha = 0.991$), Undereducation ($\alpha = 0.974$), Overeducation ($\alpha = 0.981$), and Skill Utilization ($\alpha = 0.985$), all exceeding the 0.70 threshold. Descriptive statistics show mean scores near the midpoint (Job-Education Mismatch-2.99, Under-

Education-3.05, Over-Education-2.99, Skill Utilization -3.00), indicating neutral perceptions with moderate variation. Correlation analysis revealed moderate positive relationships between Skill Utilization and both Undereducation ($r = 0.481$, $p < 0.01$) and Over-Education ($r = 0.453$, $p < 0.01$). This indicates that mismatched employees continue to use their skills, possibly through informal learning mechanism or adaptive job behaviors.

In regression analysis the ANOVA table confirmed that the model is statistically significant ($F = 146.94$, $p < 0.001$), reinforcing the predictive strength of the relationships as clearly presented in the table 2. Regression analysis showed that both Undereducation ($\beta = 0.281$, $p < 0.001$) and Overeducation ($\beta = 0.252$, $p < 0.001$) exert a statistically significant influence on Skill Utilization. These results suggest that even mismatched employees actively use their skills, with both mismatch types contributing to variations in skill utilization among industrial workers in Gampaha District. In the regression analysis model summary, as clearly presented in the table 1, the R Square value of 0.412 suggests that 41.2% of the variation in Skill Utilization is explained by job-education mismatch variables.

Table 1: Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.642	0.412	0.407	0.492

Source: Survey Data, 2025

Table 2: Anova

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	106.724	3	35.575	146.94	0.000
	Residual	152.648	380	0.402		
	Total	259.372	383			

Source: Survey Data, 2025

The hypotheses testing results confirm that both forms of job-education mismatch significantly impact skill utilization. H1 and H2 were accepted, as both under-education and over-education showed statistically significant effects on skill utilization ($p = 0.000$).

4. Conclusion

The study confirms both overeducation and undereducation have a statistically significant affect skill utilization among industrial workers in the Gampaha District, Sri Lanka. Mismatched employees tend to adapt through informal learning and role modifications, maintaining active skill use despite educational misalignment. This highlights workforce flexibility and challenges the assumption that mismatch always leads to skill wastage. However, these positive adaptations may not guarantee long-term job satisfaction, career advancement, or organizational efficacy. Overeducated employees remain at risk of underemployment and occupational dissatisfaction, while undereducated employees may encounter role strain and restricted career progression. The study's scope was limited to a single district and industrial sector, and factors like organizational support and training were not

considered, may also influence skill utilization. In conclusion, employers should offer ongoing training and career development to support mismatched workers, while policymakers and educational institutions need to better align curricula with labor market competencies. Future research should investigate the longitudinal effects of mismatch and include qualitative insights and broader sectors to deepen understanding of its impact on skill utilization.

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FACTORS INFLUENCING BEHAVIOURAL INTENTION TO USE MOBILE BANKING SERVICES AMONG BANK CUSTOMERS IN PUTTALAM DISTRICT, SRI LANKA

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ABSTRACT

Mobile banking has revolutionized the financial sector by providing unprecedented convenience and efficiency to bank customers. In this study investigates the factors influencing behavioural intention to use mobile banking services among bank customers in Puttalam District, Sri Lanka. The rapid adoption of mobile banking technologies reflects global trends, but specific regional factors play a critical role in shaping user behaviour. The present study has used four main dimensions for independent variable namely Perceived Usefulness (PU), Perceived Ease of Use (PEU), Perceived Compatibility (PC), and Perceived Trust (PT) based on the Technology Acceptance Model (TAM). A structured questionnaire was distributed among 384 mobile banking operators of eight selected banks in the Puttalam district using the convenience sampling method. According to the correlation Analysis, all independent variables demonstrated strong positive and significant relationships with Behavioural Intention. Also, the regression findings confirm that there is a significant impact of determinants on the behavioural intention to use mobile banking. The study provides valuable insights for banking institutions, policymakers and technology developers, highlighting the importance of strategies developed to enhance mobile banking in the region.

Keywords: *Mobile Banking. Behavioural Intention, Bank Customers, Puttalam District*

1. Introduction

The rapid advancement of financial technologies has transformed the banking sector, shifting from traditional, and in-person transactions to digital platforms such as mobile banking (m-banking). This study investigates the factors influencing the behavioural intention to use mobile banking services among banking customers in the Puttalam District of Sri Lanka. Although mobile banking is widely available and the number of mobile phone and internet users is increasing, the adoption rate of mobile banking in rural regions like Puttalam remains relatively low. This presents a significant concern for financial institutions seeking to increase digital engagement among customers. (Department of Census and Statistics, 2012).

Existing literature suggests that despite technological accessibility, the actual usage of mobile banking is lower than anticipated, particularly in both developing and developed countries (Nawaz & Yamin, 2018) (Ravichandran & Madana, 2016). According to Venkatesh and Davis (2000), perceived usefulness and ease of use are fundamental drivers of behavioural intention. Furthermore, Rogers (2003) and Chen (2008) emphasize that perceived compatibility, reflecting how well an innovation aligns with users' values and lifestyle, is a critical determinant. Additionally, trust in mobile services particularly in financial transactions has been repeatedly identified as a significant factor influencing technology adoption (Kim & Prabhakar, 2014). (Nawaz & Yamin, 2018) (Ravichandran & Madana, 2016) (Venkatesh & Davis, 2000) (Rogers, 2003) (Chen, 2008).

More specifically, this research has four objectives;

i. To identify the impact of perceived usefulness on the behavioural intention to use mobile banking among banking customers in Puttalam district Sri Lanka.
ii. To identify the impact of perceived ease of use on the behavioural intention to use mobile banking among banking customers in Puttalam district Sri Lanka.
iii. To identify the impact of perceived compatibility on the behavioural intention to use mobile banking among banking customers in Puttalam district Sri Lanka.
iv. To identify the impact of perceived trust on the behavioural intention to use mobile banking among banking customers in Puttalam district Sri Lanka.

Based on the Technology Acceptance Model, the following conceptual framework is developed;

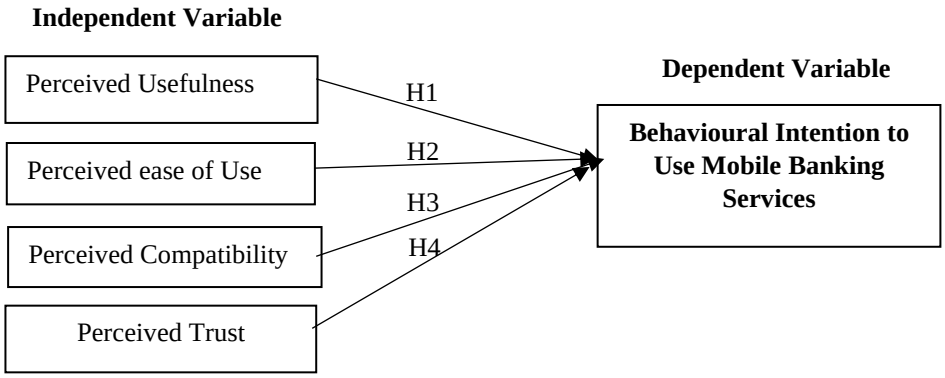

Figure 1: Conceptual Framework

Source: Venkatesh & Davis, 2000

Based on the conceptual framework, four hypotheses are developed;

H1: There is a significant impact from perceived usefulness on the behavioural intention to use mobile banking by banking customers in Puttalam district Sri Lanka.

H2: There is a significant impact from perceived ease of use on the behavioural intention to use mobile banking by banking customers in Puttalam district Sri Lanka.

H3: There is a significant impact from perceived compatibility on the behavioural intention to use mobile banking by banking customers in Puttalam district Sri Lanka.

H4: There is a significant impact from perceived trust on the behavioural intention to use mobile banking by banking customers in Puttalam district Sri Lanka.

2. Methodology

The study follows a positivist philosophy, the study adopts a deductive approach to test hypotheses derived from the Technology Acceptance Model (TAM). Specifically, it examines the influence of perceived usefulness, perceived ease of use, perceived compatibility, and perceived trust on users' intention to adopt mobile banking. To gather empirical data, a self-administered online questionnaire (hosted on Google Forms) was distributed using convenience sampling of 384 mobile banking customers. This sample size was determined using the standard formula for an unknown population at a 95% confidence level 5% margin of error. Banks covered in the survey include both state and non-state institutions. Data was collected using a self-administered questionnaire, and IBM SPSS Statistics-21 was used for analysis.

3. Results and Discussions

The sample included 384 bank customers, with 53.9% females and 45.6% males, suggesting a higher female representation in mobile banking usage in the Puttalam district. The age group 25–29 was the most dominant, contributing to 44.8% of the respondents. 55.7% of respondents were employed, and a significant portion (44.5%) earned between LKR 50,000–75,000 monthly. The majority had G.C.E. A/L (36.2%) or Diploma-level education (27.3%). Commercial Bank (27.9%) and Bank of Ceylon (27.3%) were the most commonly used banks for mobile transactions. Most respondents (42.4%) use mobile banking a few times a week, and 39.1% have been using it for 6 months to 1 year.

According to the correlation Analysis, all variables such as Perceived Usefulness, Perceived Ease of Use, Perceived Compatibility, and Perceived Trust showed strong positive correlations with Behavioural Intention, ranging from 0.621 to 0.778, all significant at the 0.01 level. This indicates that higher perceptions of usefulness, ease of use, compatibility, and trust are associated with stronger intentions to use mobile banking. Among these, Perceived Trust had the strongest relationship with Behavioural Intention ($r = 0.778$), suggesting it is the most influential factor in shaping users' intentions.

According to the model summary in regression analysis, the Adjusted $R^2 = 0.654$, which means 65.4% of the variation in behavioural intention is explained by the four independent variables. All predictors were statistically significant ($p < 0.05$) in the model. Among these, Perceived

Trust had the highest standardized beta coefficient (β = 0.491), making it the most influential factor affecting behavioural intention. These all four constructs Perceived Usefulness, Ease of Use, Compatibility, and Trust are significant influencers of the behavioural intention to use mobile banking in Puttalam district.

Table 1: Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.808	.654	.650	.32157

a. Predictors: (Constant), Perceived_Trust, Perceived_Usefulness, perceived_Essy_Of_Use, Perceived_Compatibility

Source: Survey data, 2025

Table 2: ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	73.927	4	18.482	178.734	.000
	Residual	39.190	379	.103		
	Total	113.118	383			

a. Dependent Variable: Behavioural_Intention

b. Predictors: (Constant), Perceived_Trust, Perceived_Usefulness, perceived_Essy_Of_Use, Perceived_Compatibility

Source: Survey data, 2025

4. Conclusion

This study investigated the factors influencing customers' behavioral intention to use mobile banking services in the Puttalam District of Sri Lanka, using the Technology Acceptance Model (TAM). Four independent variables perceived usefulness, perceived ease of use, perceived compatibility, and perceived trust were examined through a quantitative survey of 384 respondents from state and non-state banks. The findings highlight that customers are more likely to adopt mobile banking when it is perceived as easy, useful, compatible with their lifestyle, and trustworthy. Researcher selected Puttalam District because, Puttalam District was selected for this study due to its overwhelmingly rural character, with approximately 91% of its population residing in rural areas as per the 2012 Census. Its substantial working-age cohort (15–64 years), comprising around 66.4% of the population, represents a significant reservoir of economically active individuals who could adopt mobile banking. Moreover, despite improvements in mobile phone and internet access, no prior research has specifically examined mobile banking adoption in Puttalam District, presenting a valuable opportunity to explore usage dynamics in this underserved rural context.

The study recommends that banks enhance mobile app usability, strengthen security measures, and conduct targeted awareness campaigns, particularly in rural areas. Additional strategies include offering incentives, improving connectivity through partnerships with ISPs, and providing real-time support. Limitations include the restricted set of variables and reliance on a single model, suggesting the need for future research to explore other factors such as digital

literacy, social influence, and perceived risk. Comparative rural–urban studies, longitudinal research, and alternative models like UTAUT or TPB are proposed to provide a broader understanding of mobile banking adoption in Sri Lanka.

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THE IMPACT OF JOB SATISFACTION ON EMPLOYEE JOB PERFORMANCE IN STAR-RATED HOTELS: WITH REFERENCE TO NEGOMBO, GAMPAHA DISTRICT, SRI LANKA

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ABSTRACT

This study investigates the relationship between job satisfaction and employee job performance within selected star-rated hotels in Negombo, Sri Lanka. Because tourism is such an important part of Sri Lanka's economy, thus hotel personnel must perform well in order to maintain service standards and ensure client pleasure. The study focuses on the effect of four key elements of job satisfaction i.e., pay and compensation, promotion chances, coworker relationships, and supervision on employee performance. A structured questionnaire was used to gather data from a sample of 217 non-executive staff from three prominent hotels. Data were analyzed by using multiple regression analysis in SPSS and descriptive statistics. Reliability and validity tests, and correlation analysis also performed. . The findings showed that coworker relationships, supervision, and promotion opportunities significantly influence employee performance, while pay had no significant effect. This supports Herzberg's Two-Factor Theory, which highlights that motivators like recognition and growth enhance employee satisfaction and performance, whereas hygiene factors like pay only prevent dissatisfaction. This study provides some important insights to the topic of human resource management in the hotel industry, particularly in developing nations like Sri Lanka. The study highlights the significance of non-monetary factors in employee productivity and suggests that hotel management should shift from financial incentives to creating a supportive work environment, enhancing coworker connections, career advancement opportunities, and supervisory support.

Keywords: *Job Satisfaction, Employee Job Performance, Start-rated Hotels, Negombo*

1.Introduction

The hotel business is a pillar of Sri Lanka's tourism-based economy, contributing significantly to national GDP, job creation, and regional development. In tourist-centric places like Negombo, a coastal city near Bandaranaike International Airport, the demand for high-quality hospitality services is consistent and fierce. In a service-oriented industry, employee performance is one of the most important variables impacting visitor pleasure, service excellence, and hotel reputation (Baum, 2015). Understanding what motivates hotel staff and drives their performance is critical to ensuring operational efficiency, guest loyalty, and long-term economic success (Chi & Gursoy, 2009).

While job satisfaction has been extensively examined, most research focuses on executives or larger industries, leaving a lack for localized, role-inclusive studies, particularly in Sri Lanka's hotel sector. Despite its significance, Negombo's hospitality sector faces critical workforce challenges, including: Many employees leave due to dissatisfaction with pay, promotion opportunities, and job security (Eisenberger, 1986). Long working hours, demanding customers, and lack of career growth led to dissatisfaction. Hotel employees frequently switch industries or migrate abroad, worsening the labor shortage (Ranatunga & Dahanayake). Employee disengagement results in poor customer experiences, increased absenteeism, and reduced operational efficiency (Griffin, 1999). This study fills that gap betwen all staff levels in Negombo's star-rated hotels to better understand how job satisfaction affects performance.

Based on Herzberg's Two-Factor Theory, which distinguishes between hygienic factors (e.g., pay, work environment) and motivators (e.g., recognition, advancement), the study investigates how remuneration, promotion, coworker relationships, and supervision affect performance. The findings provide practical insights for hotel management and human resources professionals looking to improve employee satisfaction and performance at all levels. (Herzberg, Mausner, & Snyderman, The motivation to work. , 1959). Job performance is defined as the efficiency and effectiveness with which employees carry out their job duties and contribute to business goals (Schermerhorn, 1989). Locke (1976) defined job satisfaction as "a pleasurable or positive emotional state resulting from the appraisal of one's job or job experiences. Milkovich and Newman (2008) define pay as more than just monetary compensation, emphasizing its strategic role in workforce management. Promotion is the upward movement of employees within an organization, which is usually associated with increasing responsibility, higher prestige, and better pay (Petty, 1984). Coworker relationship as the social contacts and professional bonds developed by employees in the workplace (Eisenberger, 1986). Moorhead and Griffin (1999) define supervision as the advice, feedback, and leadership offered by supervisors to assist employees in performing effectively.

Research Objectives

i. To investigate the impact of pay on job performance of employees
ii. To investigate the impact of employee promotion on job performance of employees
iii. To investigate the impact of employee coworker Relationships on job performance
iv. To investigate the impact of employee supervision on job performance of employees

Conceptual Framework

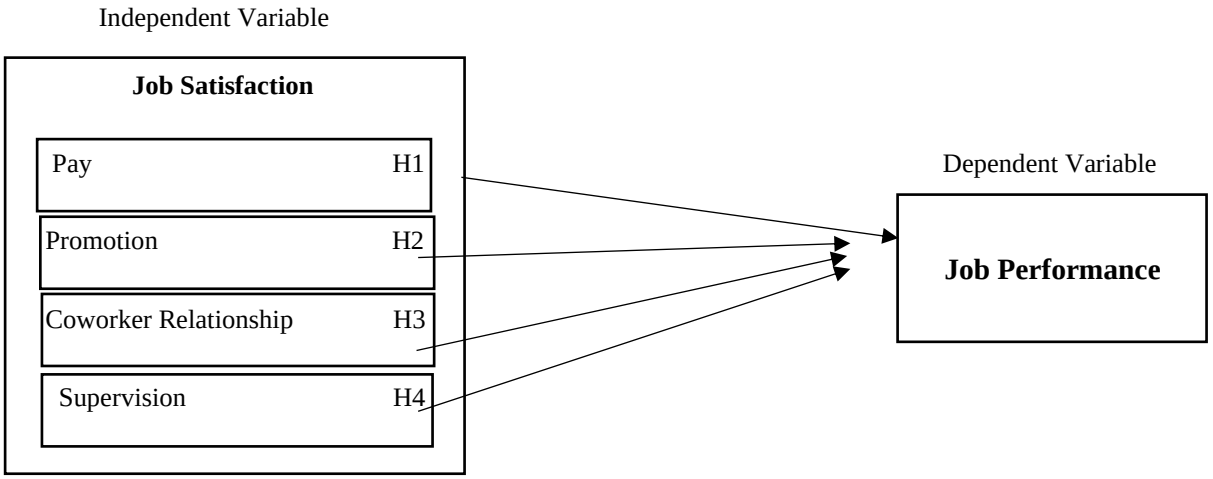

Figure 1 Conceptual Framework

Source: Herzberg, Mausner, & Snyderman, 1959

Based on Conceptual Framework, following hypotheses are developed;
H1: There is a significant impact of Pay on job performance of employees
H2: There is a significant impact of Promotion opportunity on job performance of employees
H3: There is a significant impact of Coworker Relationships on job performance of employees
H4: There is a significant impact of Supportive supervision on job performance of employees

2. Methodology

This study used a quantitative, cross-sectional design with a mono-method strategy, and the individual employee served as the unit of analysis. Employees from three star-rated hotels in Negombo were selected based on their large workforce size. Job performance was measured using a self-report perceptual scale, suitable for service employees. To ensure all employees were comparable across hotels, demographic characteristics such as age, education level, and years of experience were analyzed, supporting the assumption that the employee population was homogeneous and justifying the use of simple random sampling across all hotels (Cribbie, 2018; Sorense, 2002)The population consisted of 500 employees across three hotels: A (160), B (210), and C Hotel (130). According to Krejcie and Morgan's (1970) sample size determination table, a minimum sample of 217 employees was required. Using proportional allocation (Cochran, 1977), the sample was distributed as 70 from A, 91 from B, and 56 from C Hotel, selected through simple random sampling. Primary data were collected using a structured 5-point Likert questionnaire, and secondary data from hotel records. SPSS was used for descriptive statistics, correlation, and regression analysis to examine the impact of job satisfaction on performance.

3. Results and Discussions

A total of 217 hotel employees in Negombo were surveyed. The sample included 117 males (53.9%) and 100 females (46.1%). Most respondents were aged below 35 years (152; 70%), with 104 (47.9%) aged 26–35. Regarding education, 72 (33.2%) had diplomas and 73 (33.6%) held degrees or higher. The largest job groups were Food & Beverage Service (48; 22.1%) and

Kitchen Staff (37; 17.1%). Most respondents had 1–3 years of work experience (85; 39.2%), indicating a young workforce with moderate experience. Job performance is positively influenced by all examined factors. Pay and compensation show a weak effect (r = 0.205), while promotion opportunities (r = 0.394), supervision and management support (r = 0.355), and coworker relationships (r = 0.450) exhibit moderate to strong positive correlations.

The regression model was significant (F (4, 212) = 21.203, p < 0.001) and explained 28.6% of the variance in job performance ($R^2 = 0.286$). Coworker relationships (β = 0.306), promotion opportunities (β = 0.252), and supervision/support (β = 0.189) significantly influenced performance, while pay had an insignificant effect (β = -0.090).

Table 1: Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.535a	.286	.272	.478

a. Predictors: (Constant), Supervision and Management Support, Promotion Opportunities, Coworker Relationships, Pay and Compensation

Source: Survey data, 2025

Table 2: ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	19.374	4	4.843	21.203	.000
	Residual	48.427	212	.228		
	Total	67.801	216			

a. Dependent Variable: Job Performance

b. Predictors: (Constant), Supervision and Management Support, Promotion Opportunities, Co-worker Relationships, Pay and Compensation

Source: Survey data, 2025

Based on the regression analysis, three of the four hypotheses were failed to reject. Promotion opportunities (p < 0.001), coworker relationships (p < 0.001), and supportive supervision (p = 0.005) were found to have a significant impact on employees' job performance in Negombo's star-rated hotels, confirming H2, H3, and H4. However, pay and compensation (p = 0.193) did not have a significant effect, leading to the failure to reject H1. These findings suggest that non-monetary factors such as career growth, teamwork, and managerial support are stronger drivers of employee performance than financial incentives.

4. Conclusion

According to this study, job performance in star-rated hotels in Negombo, Sri Lanka, is highly influenced by job satisfaction. Coworker relationships, managerial support, and possibilities for promotion are important variables; these are in line with Herzberg's Two-Factor Theory, which prioritizes internal motivators over external rewards like pay. Performance was not significantly impacted by financial incentives, which emphasizes the need for more comprehensive HR strategy. Hotel management should place a high priority on career advancement, teamwork, and supportive leadership in order to increase productivity and lower

turnover. Clear promotion routes, mentorship programs, and peer recognition campaigns are examples of practical strategies. Supervisors who receive leadership training can provide better feedback and communicate more effectively. Hotels may increase employee engagement and keep a competitive edge in Sri Lanka's tourism sector by fostering a happy and encouraging work environment.

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THE ROLE OF WORD-OF-MOUTH IN INFLUENCING CONSUMER PURCHASE DECISIONS IN THE HEALTH AND BEAUTY INDUSTRY IN WESTERN PROVINCE OF SRI LANKA

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ABSTRACT

This research investigates how traditional Word-of-Mouth (WoM) and Electronic Word-of-Mouth (eWoM) affect consumer purchase intention in Sri Lanka's health and beauty industry. It utilizes the Elaboration Likelihood Model, Theory of Planned Behaviour, and Source Credibility Theory to consider six aspects of WoM: source credibility, argument quality, usefulness, valence, volume, and trustworthiness. Although research on WoM is growing globally, empirical research continues to be lacking in Sri Lanka, especially regarding the differential influences of traditional WoM and eWoM on consumer decision-making. The research study used a quantitative, descriptive research design on consumers in the Western Province of Sri Lanka. In using Morgan's Table, a sample of 384 respondents was determined, and data collection was carried out through structured questionnaires. Overall, all statistical analysis was performed using SPSS version 23. The findings suggest that eWoM has a greater impact on consumers' purchase intention than traditional WoM. The four significant predictors out of the six dimensions are volume, source credibility, usefulness, and valence while argument quality and trustworthiness were not significant. This suggests that consumers prefer messages that are frequent, credible, useful, and emotionally positive rather than free from emotionality or logic alone where it was associated with great trustworthiness. The study was limited to one sector and one geographic location, and did not consider variables like pricing or brand loyalty. Future research should study additional sectors and parts of the world, and should incorporate moderating variables in their study designs. For practical implications, health and beauty marketers and brand managers should ensure that consumers share their product experiences to increase WOM volumes, use credible sources to enhance source credibility (e.g., micro-influencers and professionals), and provide helpful and entertaining digital content (e.g., tutorials, testimonials) to optimize WOM usefulness and valence. Furthermore, organizations can embed WOM tactics into their broader digital marketing initiatives as a suitable and culturally relevant avenue to traditional advertising, which fosters consumer trust and purchase intentions in competitive environments.

Keywords: *Consumer Purchase Intention, Digital Platforms, Electronic Word-of-Mouth, Health and Beauty, Traditional Word-of-Mouth.*

1. Introduction

The health and beauty industry in Sri Lanka's Western Province is experiencing a fundamental increase in consumer demand (Beauty & Personal Care - Sri Lanka, 2025). This increase can largely be attributed to increased awareness, greater digital connectivity and the impact of peer-to-peer interactive communication (Rathnayake & Lakshika, 2023). Traditional Word-of-Mouth (WoM) and Electronic Word-of-Mouth (eWoM) are arguably key determinants in the development of consumers' attitudes and purchasing decisions in this area. Traditional WoM is when information, opinions or recommendations about products or services are shared between consumers informally, typically during one-to-one communication or face-to-face communication (Ngoma, et al., 2019). Traditional WoM is often considered to be one of the most credible and persuasive forms of marketing communication because it comes from a peer, and not an organization. While eWoM is defined as consumer generated statements that are transmitted via the Internet including social media, online reviews, blogs, and online communities (Thurau, et al, 2004). eWoM extends beyond traditional WoM because eWoM reaches wider audiences in shorter periods of time, and influences consumer purchase intention beyond physical boundaries. Although, WoM is well known on a global scale as a powerful determinant of consumer behavioural responses, yet there is limited empirical evidence in Sri Lankan literature, particularly concerning an understanding of how eWoM informs purchase intention in a localized cultural and economic setting (Alcocer, 2017).

This study will investigate the effect of traditional WoM and eWoM on consumer purchase intention, through the following objectives:

- To examine the influence of Word-of-Mouth (traditional WoM/eWoM) on consumer purchase intention in health and beauty products in Western Province, Sri Lanka.
- To compare the impact of traditional Word-of-Mouth and that of electronic WoM on consumer purchase intention.
- To outline some of the factors of traditional WoM/eWoM responsible for bolstering effective influence on consumer purchase intention in the health and beauty sector.

All these variables they were consistently highlighted in previous research on peer pressure and consumer manipulation (Ismagilova, et al., 2020); (Erkan & Evans, 2016). They also correspond to credible theories: the Elaboration Likelihood Model (ELM) describes how consumers process WoM either through credibility and usefulness as a central route, and emotional valence and volume as a peripheral route; the Theory of Planned Behaviour (TPB) offers a rationale for linking persuasive messages to behavioural intentions such as purchase; and Source Credibility Theory explains how the trustworthiness and expertise of a source can affect consumer attitudes related to WoM.

The geographic scope of the study is limited to the Western Province and the sector of health and beauty. The study focuses only on consumer perceptions and does not factor in other considerations such as pricing, brand loyalty, or socio-economic considerations. Data were taken from respondents via a structured questionnaire that included items measuring both traditional WoM and eWoM separately, thereby allowing a direct comparison of their relative influence on purchase intention. Despite giving a more nuanced understanding of the interplay

between consumer behaviour in the context described, such a narrow lens limits the applicability of the findings to other regions and/or industry sectors.

In this research study, it analyse Word-of-Mouth (WoM) as a construct that includes traditional WoM (e.g., face-to-face recommendations and personal conversations) and eWoM (e.g., online reviews, influencer content, and social media posts). This dual perspective was incorporated in the questionnaire development as measurement items intended to capture both traditional WoM and eWoM in the same dimensions, which are source credibility, argument quality, usefulness, valence, volume, and trustworthiness.

The conceptual model represents WoM as one construct with six dimensions. Nevertheless, the operationalization of WoM in the study serves to measure and compare both traditional and electronic WoM by design. This allows for the distinct examination of each to see how they are different, and also can measure the relative strength of both forms of the single construct, as a combined independent variable in a unified model of consumer purchase intention. It is built from the Elaboration Likelihood Model, Theory of Planned Behaviour, and Source Credibility Theory. Figure 1 illustrates how each dimension is expected to have a direct positive effect on consumer purchase intention within the context of the health and beauty industry.

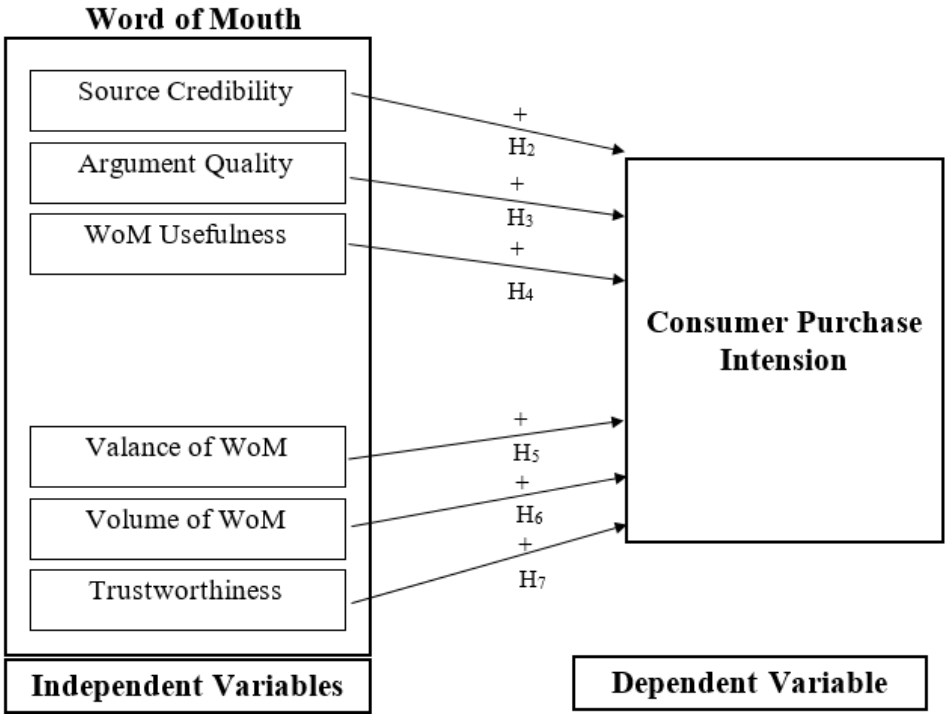

Figure 1 - Conceptual Framework

2. Methodology

This study was conducted to investigate the impact of both Word-of-Mouth (WoM) and Electronic Word-of-Mouth (eWoM) on consumer purchasing intention in the health and beauty industry. A quantitative, descriptive research design was selected, with data gathered through a structured questionnaire both online and offline, on a sample of 384 respondents from the Western Province of Sri Lanka, implementing convenience sampling. The six constructs

(source credibility, argument quality, usefulness, valence, volume, trustworthiness) were measured with validated five-point Likert scale items.

In this research, word-of-mouth (WoM) was set up to capture traditional (face-to-face, personal conversations) and electronic (online reviews, social media, influencer posts) across the six dimensions. The questionnaire included items to capture both (e.g., both personal recommendations and digital reviews were used to measure usefulness; offline feedback and online testimonials were used for valence). This way of designing the study allowed it to consider traditional and electronic WoM as opposed to complaint and recommendation in one study, and directly compare the two in the elements of usefulness and valence. The questionnaire included additional items that explicitly asked respondents to indicate which form they found more persuasive.

The data analysis was undertaken via SPSS version 23 and involved the following: descriptive statistics, tests of reliability and validity, Pearson correlation, and multiple linear regression. This provided theoretical coherence, statistical robustness, and results significant to academics and managers.

3. Results and Discussions

The study aimed to explore the effect of the different dimensions of Word-of-Mouth (WoM) as it relates to consumer purchase intention in Sri Lanka's western province (WP) in the health and beauty industry. 384 valid responses were collected and analysed using SPSS through descriptive statistics, correlation analysis, independent sample t-test, one-way ANOVA and multiple linear regression. The demographic information of respondents indicated that most respondents (55.99%) were female and primarily in the 20-30 year age group, with the majority of the respondents being at a secondary or undergraduate education level. 76.6% earned less than Rs. 100,000 per month. More than 90% of respondents stated that they purchased health and beauty products monthly or at least every few months, suggesting significant engagement in the category.

Correlation analysis indicated a strong, positive relationship between all WOM dimensions; source credibility, argument quality, WoM usefulness, valence, volume, and trustworthiness, and purchase intention (Pearson correlations from .611 to .789, $p < .01$). To compare the effect of traditional and electronic Word-of-Mouth (WoM), the items in the questionnaire were classified into two group, each containing nine questions. An independent samples t-test was conducted by leveraging those two groups, and found that eWoM had a significantly more substantial impact on purchase intention than traditional WoM ($t = 3.309$, $p = .001$; Mean difference = 0.398). This result indicates the increasing relevance of digital platforms in shaping consumer behaviour within the health and beauty sector.

Further examination through one-way ANOVA found significant differences in purchase intention based on age and income ($p < 0.001$) as well as some post hoc tests that generally indicated that younger and mid-income respondents were more affected by WOM. The multiple linear regression analysis produced an R^2 value of 0.747, meaning 74.7% of the variability in purchase intention was explained by the WOM dimensions found in the model,

specifically volume of WOM (β = 0.272), source credibility (β = 0.208), WOM usefulness (β = 0.180), and valence of WOM (β = 0.162) were all statistically significant ($p < 0.01$). However, argument quality (β = 0.081, p = 0.179) and trustworthiness (β = 0.064, p = 0.074) was not statistically significant in the regression analysis indicating possible multicollinearity or overlapping influence of other factors related to WOM.

Table 1: Regression Results

Hypothesis	Predictor	Beta	Sig	Supported?
H_1	Source Credibility	0.208	0.000	Yes
H_2	Argument Quality	0.081	0.179	No
H_3	WoM Usefulness	0.180	0.001	Yes
H_4	Valence of WoM	0.162	0.003	Yes
H_5	Volume of WoM	0.272	0.000	Yes
H_6	Trustworthiness	0.064	0.074	No

This research generally confirms an existing body of literature surrounding WOM. In particular, these findings stress the importance of the WOM message being frequent, credible, informative, and emotionally positive, in that a powerful WOM created purchase intention even when a product was otherwise unavailable. Additionally, this research does not invalidate, but rather validate, theories of the Elaboration Likelihood Model and Source Credibility Theory for the Sri Lankan consumer, where consumer decision-making is heavily influenced by peripheral cues and whom they deem trustworthy. Additionally, the study lends credible, empirical support to establish the hypothesized relationships. Therefore, the study provides meaningful contributions to consider both scholarly activity and marketing practitioner.

4. Conclusion

The findings of the study indicate that Word-of-Mouth (WoM/eWoM) significantly influences consumer purchase intentions in Sri Lanka's health and beauty industry, thus achieving the first objective in the research. This aligns with previous international research that states message power through peer communication influences consumer behaviour (Erkan & Evans, 2016).

The second objective, comparison of traditional WoM with eWoM, was also achieved. The independent samples t-test showed that eWoM has an effect of purchase intention that is statistically significantly stronger than traditional WoM ($p = .001$), with global evidence for the increased level of influence of digital platforms (Thurau, et al., 2004).

Finally, the third objective, to identify key WoM dimensions that influence purchase intention was achieved. Regression analysis identified volume, source credibility, usefulness, and valence as key predictors, consistent with earlier empirical research (Filieri, 2014); (Chen, et al., 2022), while argument quality and trustworthiness were positively associated but the

independent effects were less strong. This implies consumers valued frequency, credibility and emotional tone, more than logical persuasiveness.

Overall, these insights confirm the aims of the study and strengthen the empirical rationale, offering actionable meaning for marketers to add visibility to WOM, apply credible sources, and deliver useful and emotionally meaningful messages. Even though there is an element of limitation to the study, it adds localized evidence from Sri Lanka and forms an evidence base for future studies to further explore across industries, geographic locations, and moderating factors, such as brand trust and social media.

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THE IMPACT OF LOGISTICS SERVICE QUALITY FACTORS ON CUSTOMER SATISFACTION IN SRI LANKAN E-COMMERCE INDUSTRY

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ABSTRACT

The e-commerce industry in Sri Lanka is rapidly growing and highly competitive market. Day by day, the new competitors enter into the market. E- commerce sector companies should pay attention to their logistics service quality for better customer satisfaction. There is limited research in logistics service quality on e-commerce industry in the world. Sri Lanka has very a smaller number of research related to logistics service quality in e-commerce sector. In this research study aim to present the findings for impact of logistics service quality factors on customer satisfaction in Sri Lankan e-commerce industry. The research is quantitative and there are seven hypotheses developed based on the objectives of the research. The data collected through online questionnaire and it consists demographics questions and 5-point likert scale questions. According to sample to item ratio method, the sample size is 140. In data analysis, descriptive analysis, correlation analysis and regression analysis conducted for the identify the relationship between the variables. Based on the research findings, there is a positive impact on logistics service quality and customer satisfaction in the e- commerce industry in Sri Lanka. When comes to the limitation, there are no previous studies for assess the logistics service quality factors in the Sri Lanka specially, for the e- commerce industry. The research is conducted to the all the province in the Sri Lanka but the majority responses are in the western province and some province has no respondents. The questionnaire of this study shares through the online. Another limitation is time constraint. In this case, researcher able to collect data through small sample size. When comes to the future research areas, future researcher can get the most appropriate variables. Future researchers can increase the sample size and get more responses to analyse. Future researchers can expand their time for the research, increase sample size and add more questions to the questionnaire. In future research, the researchers can collect data through the all provinces in the country. Researchers can use another usable analysis system for analyse the data. Finally, future researchers can conduct this study in qualitative manner. The findings of this research study will help for the e-commerce managers and companies to give better service for their customers as well as achieve their organizational goals.

Keywords: *Customer satisfaction, E-commerce industry, Logistics service quality*

1. Introduction

The effectiveness of supply chain management is becoming more important in recent years. An essential aspect of supply chain management is stable high quality logistics service. The quality of logistics service, which has a greater impact on the organizational survival and continuity. In China, e- commerce logistics service quality is inadequate and it is affected to customer satisfaction (Choi et al., 2019). Akil & Ungan (2022) conducted research on e-commerce logistics service quality and customer satisfaction and loyalty and moreover, researchers mentioned "This study has certain limitations to consider in future research. Conducting an assessment with survey data includes a subjective approach. Quantitative data may be used in future studies". Ahmed (2024) identified logistics service quality have a substantial influence on consumer satisfaction in the e-commerce industry in Bangladesh. Akil & Ungan (2022) suggested "Future research can be carried out on an international scale to determine the impact of countries' social, economic, and cultural differences on customer's logistics service quality assessments". Sri Lanka is still developing country and consumer behavior is also separate from the other countries. Therefore, researcher cannot use the other research findings for the Sri Lankan customer satisfaction. According to the above points, the need for the Sri Lankan customer-based research is raised. The researcher aimed to find the relationship between logistics service quality and customer satisfaction in Sri Lankan e-commerce industry.

Customer satisfaction is not only tangible results of a product or service but also to the means surrounding the consumption experience, and a perfect or error-free process ensures an integrated perception (Hidayat et al., 2024). Logistics service quality also defines as the logistics processes between buyer and seller by creating activities such as economic utilities, possessions, utilities of time and location (Lee & Kim 2008). Logistics service quality factors are; Personal contact quality is how well the supplier's staff interact and serve their customers (Huang & Lai 2010). Order release quantity relates with product availability concept. Order accuracy refers to arrive shipment is aligned to the customer's order (Mentzer et al., 2001). Order condition is the lack of damage in the item. This is also can refers the product specification meets customer expectation (Collier & Bienstock 2006). Order quality refers how well products work. It encompasses how well the products works as mention in their specification and meet customer needs (Mentzer et al., 2001). The most important factor in the logistic service quality (LSQ**)** is timeliness**.** It is understood that the customer's order was received at the agreed time. The most critical component is "on time" delivery (Chin et al., 2013). According to Parasuraman, Zeithaml, and Berry (1985) dimensions of service quality SERVQUAL theory analyse the impact of service quality on customer satisfaction in businesses. It provides physical dimension and reliability, responsiveness, communication, assurance, humility and understanding of the customer. (Abdirada & Krishnana, 2021)

The scope of this study is limited to logistics service quality in the Sri Lankan e-commerce industry. To collect the data, a questionnaire will be distributed to e-commerce customers as a sample. Research on the quality of logistics services in Sri Lanka has been limited to the western province's Colombo and Gampaha districts, particularly in the e-commerce sector, which has not been studied. It limited to Colombo and Gampaha because the population is greater than the other provinces.

2. Methodology

The research design is correlation design. Without implying causation, this research design studies the relationship between variables. In this study the main independent variable is customer satisfaction. Dependent variable is logistics service quality factors that affected to the customer satisfaction like personal contact quality, order release quantity, Order accuracy, order condition, order quality and timeliness. The researcher will aim to analyze the Sri Lanka's e- commerce industry. According to sample to item ratio, the researcher collected 140 responses (Memon, et al., 2020). This will be done by using the quantitative questionnaire. In this study, it will be collected through carefully crafted structured survey questionnaire that aligns with our research objectives. Then for the data analysis, the IBM SPSS statistics 23.0 package will be use to analyze demographic data, ensure the validity and reliability of data and test the researcher's proposed hypothesis. Then conduct descriptive analysis. This analysis gives understanding of characteristics of data. To ensure validity and reliability of data, researcher conduct a KMO and Bartlets test and Cronbach alpha test. After, researcher will conduct a correlation analysis for get a broader understanding about the relationship between variables. Then conduct regression analysis to identify the impact between independent (Logistics service quality factors) and dependent variable (Customer Satisfaction) measures in unit wise. In this study, researcher will use the cross-sectional data and have to use many persons in single point in time.

3. Results and Discussions

3.1 Correlation Analysis

In correlation analysis, the Pearson correlation is negatively or positively greater than 0.5, it means that the variables are strongly related. If Pearson correlation is negatively or positively less than 0.5, it means the variables have weak relationship. Also, the significance value should be less than 0.05 (Senthilnathan, 2019).

Table 1: Correlation Analysis

Dependent Variable	**Independent Variable**	**Pearson Correlation**	**Significance**
Customer satisfaction	Logistics Service Quality	0.787	0.000
Customer satisfaction	Personal Contact Quality	0.579	0.000
Customer satisfaction	Order Release Quantity	0.464	0.000
Customer satisfaction	Order Accuracy	0.586	0.000
Customer satisfaction	Order Condition	0.613	0.000
Customer satisfaction	Order Quality	0.682	0.000
Customer satisfaction	Timeliness	0.662	0.000

3.2 Regression Analysis

After running regression analysis, the output for model within SPSS include four tables. There are variable entered or removed table, Model summary, ANOVA table and Coefficient table. The following tables shows the regression analysis of the research.

Table 2: Model valid for logistics service quality and customer satisfaction

	R Square	**Adjusted R square**	**Model significance**
Logistics service quality with dependent variable (Customer Satisfaction)	0.620	0.617	0.000

Table 3: Coefficients For Logistics Service Quality

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	.668	.199		3.359	.001
	Logistics Service Quality	.854	.057	.787	15.001	.000

Out of 140 responses, the majority of the respondents are female and it is 57.9%. the majority are age range between 25-34 and it is 40.7%. This represent the majority of the e-commerce users are young. Lowest respondents are in age under 18 and it is 6.4%. Most of the respondents are in the western province of Sri Lanka and it is 70%. Majority of the respondents are full time employees and lowest are self- employed. It is 56.4% and 5% respectively. Most of the respondents are rarely use e-commerce platform to shopping and it is 49.3%. Most of the respondents are prefer to shop with Temu, Daraz and Ali express. In the normality test, can be assumed population is normal and skewness and kurtosis values are normally distributed. Then come to the reliability analysis, the researcher uses Cronbach's alpha for test the reliability. All the variables are accepting the reliability test and Its Cronbach's alpha values are above the 0.5. In the validity, the researcher uses the factor analysis and all the 7 variables are accepting the validity test. All the variable's Kaiser-Meyer-Olkin measure of sampling adequacy values are above 0.5 and significance value below 0.05. when comes to the correlation analysis, all the variables significance value is less than 0.05. Out of 6 Independent variables Personal contact quality, order release quantity and order accuracy are moderate positive relationship with the customer satisfaction. Other independent variables order condition, order quality and timeliness have a strong positive relationship with the customer satisfaction. The main independent variable logistics service quality has a strong positive relationship with customer satisfaction. In regression analysis, the main independent variable logistics service quality and customer satisfaction have a significant positive relationship. The 1st hypothesis H1: There is a positive impact of logistics service quality on customer satisfaction in the e-commerce industry in Sri Lanka do not reject. Its adjusted R square is 0.617 and significance value is less than 0.05. It means the overall model is valid. When comes to the other independent variables, 4 variables are having relationship with the customer satisfaction and other 2 variable have no relationship. The hypothesis rejects can be due to survey questions because the survey

questions were taken from another countries research articles, question did not fit to the Sri Lankan context and respondents didn't understand the questions clearly. The above analysis, represent the relationship between the logistics service quality and customer satisfaction in Sri Lankan e-commerce industry. Also, it shows how sub- variables of logistics service quality impact the customer satisfaction.

4. Conclusion

When comes to the limitation, there are no previous studies for assess the logistics service quality factors in the Sri Lanka specially, for the e- commerce industry. The research is conducted to the all the province in the Sri Lanka but the majority responses are in the western province and some province has no respondents. The questionnaire of this study shares through the online. In this case, all the respondents were not significantly different and some respondents didn't understand the questions. Another limitation is time constraint. In this case, researcher able to collect data through small sample size. When comes to the future research areas, future researcher can get the most appropriate variables. Future researchers can increase the sample size and get more responses to analyse. Future researchers can expand their time for the research, increase sample size and add more questions to the questionnaire. In future research, the researchers can collect data through the all provinces in the country. Researchers can use another usable analysis system for analyse the data. Finally, future researchers can conduct this study in qualitative manner.

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THE IMPACT OF ACADEMIC MOTIVATION ON ACADEMIC PERFORMANCE DURING INTERNSHIPS: A STUDY OF MANAGEMENT GRADUATES IN WESTERN PROVINCE SRI-LANKA

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ABSTRACT

The study investigated the impact of academic motivation, intrinsic and extrinsic motivation on academic performance during the internship period of the management graduates of private and public universities within Sri Lanka's Western province. There is a significant gap in the available evidence regarding how learners sustain motivation for studies with internship responsibilities. This empirical gap underscores the need to examine the impact of motivation to performance. The objective of the study was to examine the academic motivation influence to a management undergraduate during the internship and how it affected the GPA of the undergraduates which is a bridging period. Convenience sampling which is a non-probability sampling technique was used and utilized a quantitative approach by distributing a Google questionnaire among the management graduates especially through the LinkedIn platform. 384 valid responses were analysed using SPSS version 23, and correlation analysis and regression analysis were carried out. The findings revealed that intrinsic and extrinsic motivation reported statistically significant but negative influences on academic performance during the internship period. Contrary to the prevailing literature placing intrinsic motivation against improved performance in academics, the present study observed that GPA declined with increased motivation. The study attributed this to the difficulty of internships, where students are distracted from academics to professionalism and hence academically underperform despite their motivation and also suggests that the way motivation manifests during the internships may differ from the traditional classroom settings. Although motivation plays a positive role in other circumstances it was not practical during the internship period thus there may be more impactful variables which would affect the academic performance to rise. The limitations of the study are that it was geographically confined to the western province and was limited to management graduates alone excluding other regions and disciplines. Future research should employ a broader set of motivational factors also ascertain qualitative viewpoints. This research would be beneficial to university administrators, academic advisers, internship coordinators, and policymakers with valuable implications through highlighting the need for enhanced academic support mechanisms in internships.

Keywords: *Academic Motivation, Academic Performance, Extrinsic Motivation, Internship, Intrinsic Motivation*

1. Introduction

1.1 Background

The study focused on how academic motivation impacts academic performance during the internship period among the management graduates of private or public universities in the Western Province, Sri Lanka. As internships are now a key part of university education, balancing work experience with academic responsibilities could be challenging. The main objective of this study is to examine whether the intrinsic and extrinsic motivation influence students' GPA during the internship period. For the intrinsic motivation factors, self-efficacy, altruism, and self-exploration, along with extrinsic motivational factors, rejection of alternative options, career and qualifications, social enjoyment and social pressure was utilized for the study. The problem addressed is the lack of research on how academic motivation impacts the GPA. Much of the existing literature focuses on motivation and academic performance as separate constructs rather than examining their interconnectedness in the context of work-integrated learning. Below are the objectives of the study.

1.2 Research Objectives

1. To examine the impact of academic motivation on academic performance (GPA) during internships among the management undergraduates in the Western Province of Sri Lanka.
2. To examine the impact of intrinsic motivation on academic performance during the internship period among the management undergraduates in the Western Province of Sri Lanka.
3. To examine the impact of extrinsic motivation on academic performance during the internship period among the management undergraduates in the Western Province of Sri Lanka.

1.3 Literature Review

An internship is now a required part of undergraduate degree programs. It facilitated students' seamless transition from the academic setting to the workplace (Thilakerathne & Madurapperuma , 2013).Yogendr & Andrew (2017), defined Grade Point Average (GPA) as the average of all course final grades in a program. GPA is used to assess the academic performance in many studies (Dasanayake & Jayasinghe, 2021; Ali et al., 2010; Priyadarshana & Kumari, 2020; Fernando, 2017). Academic performance is predicted by motivational factors. It is commonly believed that students with intrinsic motivation will maintain their performance and earn higher Grade Point Averages (GPAs). On the other hand, extrinsically motivated students performance will not be constant and have a low GPA (Ali et al., 2010). Moreover, Internships are affected positively towards the academic performance with improved GPA's (Thilakerathne & Madurapperuma , 2013) On the other hand, due to the time constraints, it is also observed that students completing internships during their three-year degree program are unable to perform better on their regular examinations (Mala et al., 2020). Additionally, Working more hours could negatively affect the academic performance (Carney et al., 2005).

The study examines the effects of motivation on academic performance throughout the internships concerning the management undergraduates from private and state universities in the western province of Sri Lanka. Some limitations are the regional focus, the reliance on self-reported data, as well as the lack of other academic disciplines and students from rural areas.

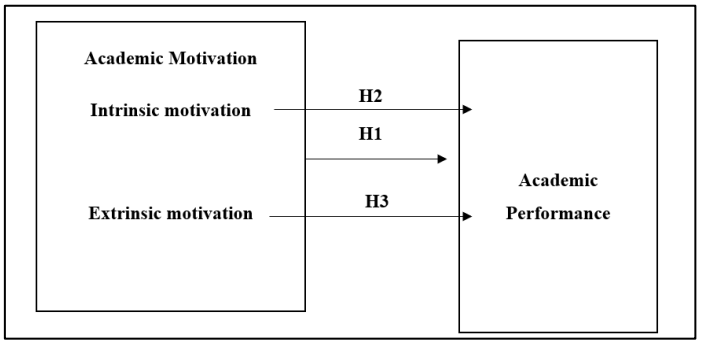

Figure 1: Conceptual framework of the study

Source: Authors work

2. Methodology

This research employed a quantitative, explanatory research design following a positivist philosophy to examine the impact of academic motivation on academic performance in internships. Convenience sampling technique is used, and data were collected through a structured questionnaire made for management graduates from public and private universities in the western province. A total of 384 responses were analysed. The questionnaire, modified from instrumentally validated research, used a 5-point Likert scale to measure intrinsic and extrinsic motivation and academic performance. SPSS version 23 was used to analyse the data, covering descriptive statistics, correlation and regression analysis. These processes were selected for conducting exact measurements of variable relationships and for obtaining reliable and generalizable results. The chosen research method is effectively meeting the research objectives and giving both theoretical contributions and practical recommendations for developing academic performance within the internship period.

3. Results and Discussions

The study revealed that intrinsic and extrinsic motivation made a statistically significant but negative contribution to academic performance during the internship. Regression analysis was used analyze the data, with intrinsic motivation ($\beta = -0.270$, $p = 0.006$) and extrinsic motivation ($\beta = -0.222$, $p = 0.001$) both strongly predicting academic performance negatively. The R^2 of the model was 0.064, or academic motivation being only responsible for 6.4% of the variance in GPA.

Table 1: Model Summary Table of The Regression Analysis

Model Summary				
Model	R	R Square	**Adjusted R Square**	**Std. Error of the Estimate**
1	.253[a]	.064	**.059**	**.755**

a. Predictors: (Constant), Intrinsic Motivation, Extrinsic Motivation

Table 2: Coefficient Table of The Regression Analysis

Coefficients[a]						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	5.050	.414		12.210	.000
	Extrinsic Motivation	-.222	.064	-.178	-3.476	.001
	Intrinsic Motivation	-.270	.098	-.141	-2.765	.006
a. Dependent Variable: Academic_performance						

These results show that during internships, the students may struggle to balance academic requirements with work demands, lowering the impact of motivation on academic performance. Balancing both academics along with a job is not easy, therefore, the competing demands of the internship would reduce the undergraduates' ability to focus on their academic responsibilities, where the motivation would not act as in a normal situation. Moreover, the negative impact and the correlation indicated that other factors could be exerting a stronger influence on academic performance during this period.

Even though the motivation is high, the GPA of the undergraduates would not increase much for most of the management undergraduates, as it was measured by the difference between the GPA before the internship and the GPA after the internship. During the internship time the undergraduates face and pass a tough time with high academic pressure and workload stress, hindering the motivation to act as in a normal way. Also, internships expose the undergraduates to the real world and industry experience, shifting their focus and attention towards the professional and career life, where the focus and attention were away from the academic performance metrics like the GPA. As the undergraduates meet new people, focus on their job tasks and has high dreams in terms of career during the internship period focusing on the academic journey was not practical for most of the undergraduates according to the present findings. Although the undergraduates are intrinsically or extrinsically motivated the lack of time that they had for focusing on their academics is very limited during the internship period. Furthermore, students may choose to gain practical know-how and networking contacts rather

than enjoy high grades. This shift in priorities may explain why even highly intrinsically motivated students exhibit declined GPA's during the period. Also, students who are extrinsically motivated can be hindered when extrinsic rewards such appreciation and rewards are downplayed throughout the internship experience, making academic motivation less potent as a predictor of academic performance.

4. Conclusion

The findings of the study indicate that while academic motivation was meant to enhance overall academic performance, throughout the internship period, both intrinsic and extrinsic motivation had a negative impact on the students' GPAs. This means that the competing demands of internships have the ability to lower the attention of students on academic work, regardless of their motivation level. These results are contrary to general expectations in the literature, where motivation tends to have a positive impact with performance. The study highlighted that academic motivation was not a strong predictor of academic performance during internship, and other factors stress, time scarcity, and shifting priorities play a stronger role. It is recommended, based on these results, that universities provide additional academic support and flexibility during students' internships. Future research must deal with other influencing variables such as mental health, time management, and institutional support, in addition to expanding the study to other regions, disciplines and qualitative methods for detailed data. The findings of the study have multiple practical implications. Educational institutions need to restructure internship modules to offer greater academic assistance, including lighter coursework during internships, flexible testing, and guidance. Employers and internship coordinators need to work together to learn about the academic requirements that interns face, perhaps by implementing flexible work hours or academic leave days. For students, time management skills, stress management and academic planning programs at internship levels would make them academically oriented. In general, the outcomes require a combination of academic learning and hands on training in undergraduate courses in a balanced proportion.

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THE IMPACT OF AI-DRIVEN GAMIFICATION ON CONSUMER ENGAGEMENT IN SRI LANKA'S E-COMMERCE SECTOR

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ABSTRACT

Amid Sri Lanka's rapid transition to digital retailing, e-commerce platforms are increasingly incorporating gamified, AI-driven elements to attract customers and develop loyalty, but empirical understanding around how these approaches result in quantifiable engagement remain limited (Sivarajah, et al., 2024). Guided by Self-Determination Theory; Flow Theory; and the Technology Acceptance Model, this study explores the impact of personalization, adaptive challenges, rewards, and social interaction on consumer engagement in Sri Lankan e-commerce. A structured questionnaire was conducted with an online shopper sample (N=391). The data was analysed in SPSS version 23 with reliability testing, exploratory factor analysis, Pearson correlations, Welch's ANOVA, Games–Howell post hoc comparisons, and multiple regression. Reliability (Cronbach's alpha > 0.78) and validity (KMO > 0.77) were good for all constructs. Correlation analysis demonstrated significant positive relations between each dimension of gamification and customer engagement, and regression analysis confirmed that social interaction ($\beta = 0.517$) was the dominant predictor of customer engagement, followed by personalization, adaptive challenges, and rewards, all together accounting for 72.5% of the variance explained. The findings corroborate with existing literature in this area, confirming that socially interactive gamification substantially improves online engagement through promote a sense of belonging and peer motivation (Kusumawardani, et al., 2023). The findings also suggest that e-commerce platforms are ideally positioned to increase engagement via gamified social ecosystems, personalized experiences, and calibrated challenges, with marketers focusing on a combination of extrinsic incentives and intrinsically motivating social play to maximize retention of rewards, and policy makers ensuring ethical and transparent data usage as personalization evolves. While limited in geography, design, and by self-report methods, this research provides timely information on AI-gamification in an emerging market while providing a practical blueprint for engagement for digital retailers in Sri Lanka.

Keywords: *Adaptive Challenges, AI-gamification, Artificial Intelligence, Consumer Engagement, E-commerce, Personalization, Rewards, Social Interaction*

1. Introduction

The e-commerce industry in Sri Lanka has rapidly evolved, due to increased internet insights, usage of digital payments & advances in consumer lifestyles. Nevertheless, the ongoing challenge online retailers must face is maintaining high levels of consumer engagement within an increasingly competitive marketplace, where traditional promotional strategies do not appear to create long-term loyalty (Tanrıkulu & Demirel, 2023). As a consequence, organisations are now exploring methods of engagement that incorporate engaging and gamified shopping experiences through the adoption of Artificial Intelligence (AI)-based gamification topics. It is noteworthy that meta-analyses have revealed personalized prompts may increase click through rates by 20–30% and that social features, such as leaderboards, may double the likelihood of return visits to websites/sources. Unfortunately, much of this evidence comes from studies in China or Western contexts, indicating the need for contextual validation in South Asia (Zhang, et al., 2021). However, while there is a wealth of global evidence indicating that gamification can enhance consumer motivation, loyalty, and buying behaviours (Mominzada, et al., 2021), there is currently limited empirical studies examining gamification in Sri Lankan e-commerce research. Therefore, this is a significant research problem, since there is limited evidence for local businesses to explore best practices regarding effective adoption of gamification mechanisms.

The study's main objective was to assess the effect of AI-based gamification on consumer engagement in the Sri Lankan e-commerce sector. More specifically, the study aimed; to determine which AI based gamification methods are utilized the most in the Sri Lankan context and assess their effect on consumer engagement, to examine consumer experiences of gamification features and their effectiveness in enhancing a better online shopping experience, and to identify the opportunities for e-commerce platforms in Sri Lanka to implement AI-based gamification successfully. The study was backed by Self-Determination Theory; argues that autonomy, competence and relatedness fuel intrinsic motivation that AI can satisfy these via tailored quests and social leaderboards, Flow Theory; posits that optimal challenge, skill alignment elicits deep absorption, adaptive algorithms sustain this balance, and Technology Acceptance Model (TAM); links perceived usefulness, ease-of-use to adoption; personalized interfaces enhance both, which provided theoretical support to study the interaction between gamification mechanics and consumer psychology and behaviour.

An increasing number of studies have identified personalization, adaptive challenge, reward, and a sense of socially interacting as factors that can lead to engagement (Elmashhara, et al., 2023); (Bitrián, et al., 2021). While personalization and adaptive challenge utilize AI to create personalized experiences in real-time, rewards and social interaction provide extrinsic and intrinsic motivations to encourage continued use (Paschmann, et al., 2024); (Dikcius, et al., 2020). However, many of these studies are conducted in Western or high digital contexts, leaving an important question to be answered whether these aspects/function together in emerging markets such as Sri Lanka, as the countries' digital maturity, cultural values and consumer expectations differ significantly.

The research was confined to Sri Lankan online shoppers, where data was collected through a structured survey of 391 respondents. While the research adds important new evidence to the

body of literature, and has practical implications for businesses, the cross-sectional nature of the study does not allow for any causal inferences, and self-reports are prone to biases. Further, the findings may not be directly generalizable to a global setting because of the unique cultural and economic conditions inherent to Sri Lanka. Regardless of these limitations, the current research brings timely and relevant insights into how AI-driven gamification can enhance consumer engagement in an emerging digital economy.

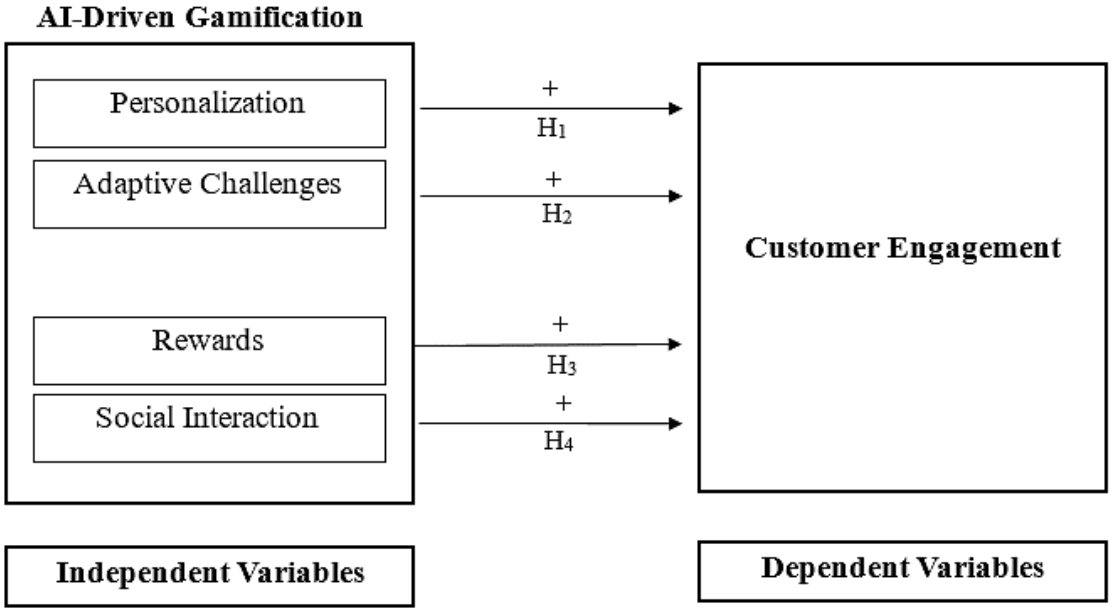

Figure 1: Conceptual Framework

2. Methodology

This study investigates that how Artificial Intelligence (AI)-driven gamification strategies have on consumer engagement in the Sri Lankan e-commerce sector. A quantitative, descriptive research design was utilized and data has been collected using a structured questionnaire administered online and offline targeting 391 respondents from over the Sri Lanka, via convenience sampling. The five constructs measured were personalization, adaptive challenges, rewards, social interaction, and customer engagement; Each construct was operationalized with validated five-point Likert scales.

The questionnaire used validated five-point Likert scale items to find key constructs, including personalization, adaptive challenges, rewards and social interaction. The following types of analyses were conducted: descriptive analysis, reliability test, validity test, Shapiro-wilk test and multiple linear regression, using SPSS version 23.

The quantitative, descriptive research design was use to measure relationships between variables and infer generalizable conclusions within the larger population of study. Utilizing standardized scales allows the study to theoretically relate, while analyses utilizing statistics offer a strong data based insight that may be relevant for both academics and managers.

3. Results and Discussion

The study aimed to explore the effect of the different dimensions of Artificial Intelligence (AI)-driven gamification as it relates to consumer engagement in Sri Lankan e-commerce sector. 391 valid responses were collected and analysed using SPSS through descriptive statistics, correlation analysis, one-way ANOVA and multiple linear regression. The demographic information of respondents indicated that most respondents (64.19%) were female and primarily in the 20-30 year age group, with the majority of the respondents being at a diploma or undergraduate education level. 72.1% earned less than Rs. 100,000 per month. More than 53.1% of respondents stated that they do online shopping occasionally, suggesting significant engagement in the category.

Correlation analysis in this study showed a strong positive relationship between all levels of AI-driven gamification—personalization, adaptive challenges, rewards, and social interaction—and consumer engagement. The Pearson correlation coefficients ranged from .623 to .781 ($p < .01$), indicating that all four measures of gamification likely have an important role in shaping user behavior and increasing engagement with e-commerce platforms. This representation provided clear support for the theoretical propositions based on Self-Determination Theory and Flow Theory, in which personalized tailoring and adaptive challenge enhance users' sense of competence and autonomy, while social interaction meets users' need for relatedness. Follow-up analysis with Welch's ANOVA indicated significant differences in consumer engagement across demographic categories; namely age and monthly income. The Games-Howell post hoc analysis indicated that younger respondents had consistently higher engagement compared to the older groups, while those in higher income ranges reported greater levels of responsiveness to the AI-driven gamification features. There were no significant differences related to gender and educational level, indicating that engagement with gamified e-commerce features was more uniform across these groups.

The regression analysis also supported the results, with the R^2 value of 0.725 indicating that 72.5% of the variance in consumer engagement was explained by the four gamification dimensions; social interaction ($\beta = 0.314$, $p < .001$) emerged as the most significant predictor, followed by personalization ($\beta = 0.276$, $p < .001$), adaptative challenges ($\beta = 0.241$, $p < .001$), and rewards ($\beta = 0.198$, $p < .001$). Each of the predictors reached statistical significance, thereby confirming that AI-driven gamification could have a total effect. Clearly, socially interactive and personalized features are incredibly influential when designing for consumer engagement in Sri Lanka's e-commerce industry.

Table 1: Hypotheses Testing Summary

Hypothesis	**Predictor → Engagement**	**β**	**p**	**Result**
H1	Personalisation	.198	<.001	Supported
H2	Adaptive Challenges	.141	.003	Supported
H3	Rewards	.111	.008	Supported
H4	Social Interaction	.517	<.001	**Strongly** supported

This study generally supports the existing body of research on AI-based gamification and consumer engagement. Specifically, the current study highlights the importance of personalization, adaptive challenges, rewards, and social interaction, showing that gamification elements are a significant driver of engagement, even in competitive online environments. Further, this study supports existing theoretical models, such as Self-Determination Theory, Flow Theory, and the Technology Acceptance Model, among others, in the Sri Lankan e-commerce setting, establishing that consumer decision making (how consumer make a decision regarding a platform or product) and platform engagement (how consumers evaluate the platform as a whole) are primarily influenced by intrinsic motivation, optimal challenge and perceived usefulness. In summary, the current study presents credible empirical evidence that provides meaningful contributions to the scholarly community and practice.

4. Conclusion

The findings of the study indicate that AI-driven gamification significantly enhances consumer engagement in Sri Lanka's e-commerce sector, thus accomplishing the first goal of identifying the influence of gamification strategies in influence consumer's behaviour in online shopping. This study also reinforces findings from prior studies that demonstrate gamification can influence engagement strongly through perceived usefulness and ease of use in Sri Lankan e-tailing (Rajumesh Sivarajah, Mahadevan Karunanithy, Konalingam Kajenthiran, 2023).

The second objective, assessing consumer perceptions of personalization, adaptive challenges, rewards, and social interaction, was also achieved. All four constructs positively predicted engagement in a regression analysis, with social interaction as the most salient predictor. This finding is consistent with global evidence highlighting that competition and cooperation mechanisms in gamified systems strongly predict user engagement (Wen, et al., 2023).

In conclusion, the third objective, to determine opportunities and challenges associated to AI-based gamification implementation, was accomplished by showing how personalized rewards and adaptive tasks promote repeat use and loyalty, while variation in consumer preferences creates challenges to implementation. These insights match international studies that note that AI-enabled gamification can dynamically adapt mechanics and feedback to enhance engagement outcomes (Abdurazzakova, et al., 2024).

Overall, the results confirm the study research objectives and add to the knowledge of how the gamification of consumer engagement can be achieved in emerging markets through the use of AI. Furthermore, the results have practical implications for Sri Lankan e-commerce platforms, digital marketers, and policymakers, while also providing evidence which is situated in Sri Lanka but supports frameworks at a global level. Overall, while careful consideration was given to the limitations of the research in terms of focus and self-reporting, this research adds some strong empirical work towards further studies in other industries, demographic settings, and identified moderating variables related to digital literacy and trust.

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BLOCKCHAIN-BASED TRIPLE-ENTRY ACCOUNTING IN SRI LANKA'S FINANCIAL SECTOR: EXPLORING ADOPTION, BARRIERS, AND USER SATISFACTION

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ABSTRACT

Blockchain technology has emerged as a transformative force in the accounting domain, particularly through its application in triple-entry accounting (TEA) systems. This study investigates the adoption potential, perceived barriers, and user satisfaction surrounding blockchain-based TEA in Sri Lanka's financial sector. The research addresses a significant gap in regional studies by evaluating how technological readiness, organizational preparedness, and regulatory frameworks affect TEA adoption in an emerging economy context. A structured survey targeting 384 financial professionals provided the primary data. Descriptive and inferential statistics, including regression and mediation analyses, were employed to test hypotheses derived from the Technology Acceptance Model and Diffusion of Innovation theory. Key findings reveal a cautiously optimistic stance among financial professionals toward TEA adoption, hindered by infrastructural limitations, regulatory ambiguity, and implementation costs. Despite these challenges, the study identifies user satisfaction in terms of system ease of use, reliability, and security as a mediating factor that significantly influences adoption intention. The results underscore the need for robust institutional support, policy reform, and capacity building to enable successful TEA implementation. The study contributes to academic discourse by filling a regional research gap and offers practical recommendations for stakeholders in Sri Lanka's financial industry seeking to embrace blockchain-enabled innovation.

Keywords: blockchain accounting, triple-entry accounting, financial technology, user satisfaction, Sri Lanka

1. Introduction

Accounting systems have evolved significantly from the single-entry system, which tracked only cash flows, to double-entry systems that revolutionized transparency and accuracy. In today's digital era, triple-entry accounting, underpinned by blockchain technology, has emerged as a credible response to demands for higher transparency and fraud mitigation. TEA allows for a cryptographically signed third entry, recorded in a shared distributed ledger, offering immutable, real-time verification of financial transactions. While developed economies have initiated such transitions, Sri Lanka's financial sector remains hesitant, bound by legacy systems and regulatory inertia. This study seeks to fill that void by investigating TEA's adoption feasibility in Sri Lanka, its inhibitors, and the satisfaction levels of prospective users.

The literature underscores blockchain’s promise in financial reporting: decentralization, tamper-proof records, and real-time auditability. Nugraha and Sasongko (2024) and Pontoh and Ferdiansah (2023) (Grace Theresia Pontoh, 2023) identify cost, regulatory ambiguity, and technical skill shortages as critical barriers. Maiti et al. (2024) highlight frameworks integrating blockchain with smart contracts and edge computing, while emphasizing user-centric gaps. Though adoption benefits like fraud reduction and efficiency are well documented, empirical studies in the Sri Lankan context are minimal. Additionally, the mediating role of user satisfaction remains underexplored in previous regional studies. (Nugraha, 2024)

This study examines blockchain-based triple-entry accounting (TEA) adoption in Sri Lanka's financial sector but faces several limitations. These include a narrow geographic and industry scope, lack of formal blockchain regulations, data and technical constraints, and potential response bias from participants unfamiliar with TEA. The study does not cover practical implementation, relying instead on secondary data and expert insights. Despite these challenges, it presents a valuable, evidence-based model for guiding policy decisions, industry adoption strategies, and future research efforts. (Moinak, 2021) This study looks at how blockchain is being adopted in Sri Lanka's small, developing, and heavily regulated financial sector. The absence of clear blockchain accounting rules creates uncertainty, leading to hesitance. Limited digital infrastructure, smaller capital bases, and fewer IT specialists also hinder adoption. Economic instability and foreign exchange issues add to the challenges.

2. Methodology

The study employed a positivist, deductive research paradigm with a quantitative design. Data was collected through structured questionnaires distributed among 384 financial professionals from banking, corporate finance, and regulatory institutions. Stratified random sampling ensured sectoral representation. Variables included perceived ease of use, security, organizational readiness, and legal clarity. Cronbach’s alpha confirmed instrument reliability (>0.70). SPSS was used for data analysis, employing descriptive statistics, Pearson correlations, multiple regressions, and mediation analysis to validate hypotheses.

3. Results and Discussions

Descriptive statistics revealed a generally neutral stance among respondents. Table 1 displays mean values ranging from 2.91 to 3.13, indicating tentative optimism. Technological readiness and system reliability scored slightly higher than implementation costs and regulatory clarity.

Table 1: Descriptive Statistics for Key Constructs

Construct	Mean	Std. Dev
Perceived Ease of Use	3.01	1.02
System Security & Reliability	3.08	1.05
Organizational Readiness	2.99	1.03
Regulatory Clarity	2.94	1.04
User Satisfaction	2.92	1.01
Adoption Potential	3.00	1.02

Multiple regression analysis confirmed the hypotheses. User satisfaction significantly predicted adoption intention, while barriers such as cost and regulatory uncertainty showed a negative association. Mediation analysis revealed that user satisfaction partially mediated the relationship between organizational readiness and adoption potential, supporting the conceptual framework. The results show an overall neutral but cautiously positive attitude toward blockchain-based triple-entry accounting among financial professionals in Sri Lanka. Respondents identified the potential advantages of the technology, particularly in terms of system security and organizational readiness, but were concerned about regulatory clarity and overall user satisfaction. The enthusiasm and caution reflect the industry's acceptance of blockchain's promise tempered by restraint due to systemic uncertainties and practical usability concerns. Regression analysis provided further insights, confirming the hypotheses that had been developed from the conceptual model. User satisfaction was the most potent positive determinant of adoption intention, pointing to the importance of aligning system design and function to the needs of end-users. On the other hand, barriers such as extortionate costs, regulatory ambiguity, and poor digital infrastructure were negatively associated with adoption potential, resonating with earlier research in the literature that contextual barriers are strongest in emerging economies. Cumulatively, the results highlight that successful adoption in Sri Lanka involves a dual emphasis: strengthening institutional preparedness and, concurrently, developing user trust, satisfaction, and regulatory transparency.

Table 2: Summary of Hypothesis Testing

Hypothesis	Result
Barriers negatively influence adoption	Supported
User satisfaction positively influences adoption	Supported
Satisfaction mediates readiness and adoption	Supported

These findings align with international literature, confirming the theoretical relevance of TEA and Diffusion of Innovation in the Sri Lankan context. However, local challenges, such as limited digital infrastructure and ambiguous legal frameworks remain key inhibitors. Table 2 presents the summary of hypothesis testing, all of which were supported by the data analysis. These outcomes confirm the validity of the proposed conceptual framework and highlight

critical factors influencing the adoption of blockchain-based triple-entry accounting in Sri Lanka's financial sector.

Firstly, the finding that barriers negatively influence adoption reinforces the view that high implementation costs, regulatory uncertainty, and limited technological readiness can hinder the willingness of organizations to embrace innovation. Despite the global push toward digitization, these barriers remain particularly significant in developing countries like Sri Lanka, where infrastructure and regulatory ecosystems are still evolving. Secondly, the hypothesis that user satisfaction positively influences adoption was also confirmed. This supports the Technology Acceptance Model which posits that a user's perception of a system's ease of use and usefulness directly impacts their willingness to adopt it. Satisfied users those who find the system secure, reliable, and intuitive are more likely to endorse its use within their institutions. Thirdly, user satisfaction was found to mediate the relationship between organizational readiness and adoption. This means that even if an organization is technically prepared, the system is unlikely to be adopted unless users find it satisfactory and beneficial. This result highlights the importance of user experience in driving technology acceptance.

4. Conclusion

This study advances understanding of blockchain-based triple-entry accounting adoption in Sri Lanka by highlighting the complex interplay between user satisfaction, institutional preparedness, and systemic barriers. It provides empirical validation for existing technology adoption models in a developing country context and emphasizes the centrality of user perspectives. For policymakers, the findings suggest a need for clearer regulatory frameworks and investment in digital infrastructure. Financial institutions should focus on capacity building and change management to ease resistance. Future research should explore longitudinal adoption trends and pilot implementations to assess real-time system performance and stakeholder experiences. The study also highlights the significance of future research incorporating pilot tests and field trials to ascertain adoption behaviour validation in application environments This study advances understanding of blockchain-based triple-entry accounting adoption in Sri Lanka by highlighting the complex interplay between user satisfaction, institutional preparedness, and systemic barriers. It provides empirical validation for existing technology adoption models in a developing country context and emphasizes the centrality of user perspectives. For policymakers, the findings suggest a need for clearer regulatory frameworks and investment in digital infrastructure. Financial institutions should focus on capacity building and change management to ease resistance. Moreover, awareness programs and training initiatives must be introduced to educate stakeholders on the benefits and functionality of blockchain technologies. Collaboration between government agencies, academic researchers, and private sector actors will be vital in shaping a practical implementation roadmap. Attention should also be given to ensuring data privacy, cybersecurity, and legal enforceability of digital records. Future research should explore longitudinal adoption trends and pilot implementations to assess real-time system performance and stakeholder experiences. Additionally, comparative studies across regions and financial sectors could provide further insight into context-specific drivers and challenges.

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A STUDY ON THE INFLUENCE OF SOCIAL MEDIA USAGE ON THE ACADEMIC INTERESTS OF PRIVATE UNIVERSITY STUDENTS IN THE WESTERN PROVINCE OF SRI LANKA

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ABSTRACT

In this study, social media usage is examined in relation to academic interests of students at private universities in the Western Province of Sri Lanka. A growing reliance on digital platforms raises concerns regarding their educational benefits and potential distractions. Social media usage, study habits, distractions, and learning engagement were examined in relation to students' academic interest. The study was conducted using a quantitative, cross-sectional approach using a structured online questionnaire distributed to 162 students. Based on the descriptive statistics, social media usage and distraction were moderate, while studying habits, learning engagement, and academic interest were low. Using multiple regression analysis, it was revealed that social media usage negatively impacted academic interest, whereas study habits and learning engagement positively impacted academic interest. Distraction did not have any significant influence on academic interest. In addition to emphasizing cognitive and behavioural factors, the results support the relevance of digital engagement strategies. Academic interest is most strongly predicted by structured learning engagement and consistent study habits, while social media plays a moderate role. Educational and policymakers should consider the implications of these insights when striving to balance digital integration with academic motivation.

Keywords: *Academic Interest, social media, Learning engagement, Distractions*

1.Introduction

Rapid advancements in digital technology have revolutionized the way students access and interact with information. Particularly social media has emerged as a powerful tool for collaboration, information sharing, and communication. The increasing use of social media platforms like Facebook, YouTube, and WhatsApp among Sri Lankan private university students has both academic and recreational benefits. Nevertheless, it remains a question whether these social media platforms are genuinely enhancing academic interest or merely serving as distractions.

In prior studies such as (Mapa & Nawarathna, 2021), social media have been found to be valuable when used for academic purposes (Wahid & Sajiharan, 2019) argue, however, that social media's entertainment aspect undermines its educational value. Considering these contrasting perspectives, this study examines how social media usage affects students' academic interest and how it interacts with factors such as study habits, distractions, and learning engagement.

Specifically, this study focused on private university students in Sri Lanka's Western Province. In addition to geographical limitations, this study used a cross-sectional design, which limits its generalizability. However, it provides valuable insight into how digital behavior shapes academic motivation in a rapidly changing educational environment.

2. Methodology

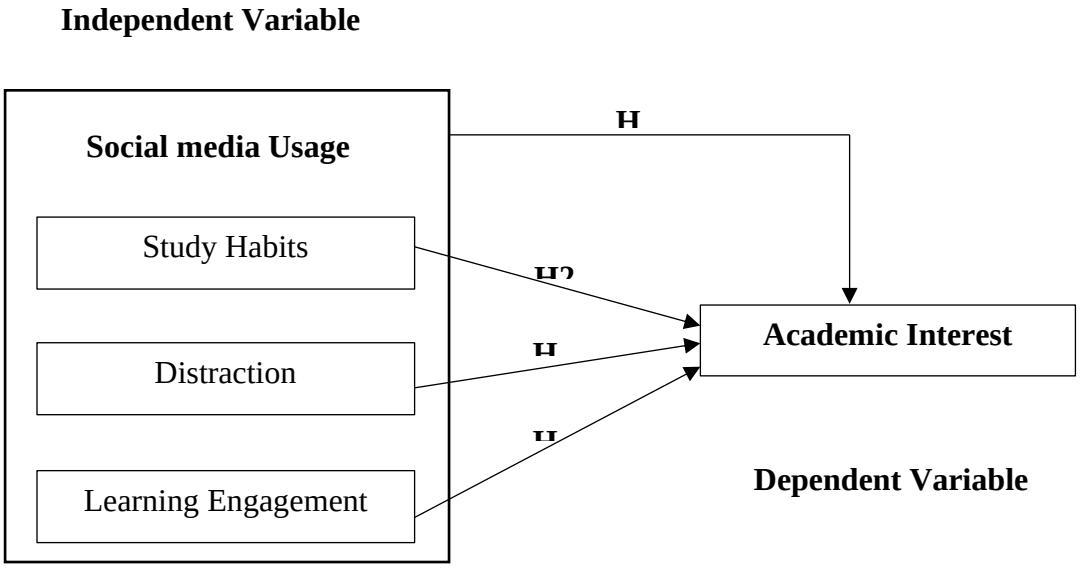

Figure 1: Conceptual Framework

The aim of the study was to investigate the impact of social media on the academic interests of students studying in private universities from Western Province of Sri Lanka using quantitative cross-sectional research approach. A sample of 162 students was selected through convenience sampling and data was collected using a structured self-administered online questionnaire.

The questionnaire comprised of five key constructs which were measured on a five-point Likert scale. These constructs include social media usage, study habits, distraction, learning

engagement, and academic interest. All the constructs were measured using validated instruments which were modified to fit the local context when required.

The data was summarized using descriptive statistics. Furthermore, the relationships among the independent variable's social media usage, study habits, distraction, and learning engagement with the dependent variable, academic interest, were examined using multiple linear regression analysis in SPSS.

Based on the chosen methodology, statistical relationships could be established and assessed while population trends could be identified in a short amount of time. The study achieved its intended goals of advancing theoretical knowledge as well as providing practical value by using quantitative methodologies. The research design was further strengthened through its grounding in established theoretical frameworks, such as the Uses and Gratifications Theory, which explains students' motivations for engaging with social media; The Cognitive Load Theory emphasizes the impact distractions have on focus and learning; the Self-Determination Theory explains how intrinsic and extrinsic motivations are balanced; and the Theory of Planned Behaviour explains how attitudes, norms, and perceived control impact student academic interest. As a result, these theories enabled a robust interpretation of the findings and provided a framework for situating them within a broader academic discourse.

3. Results and Discussions

On average, participants reported their social media use as moderate (M = 2.80) alongside moderate levels of distraction (M = 2.70). In comparison, the mean values of study habits and learning engagement were both 2.40, with academic interest slightly higher at 2.60. These findings suggest that students' engagement with social media, at least at this level, tends to be unidirectional, and does not improve academic motivation or behavior.

Table 1: Regression Results

Hypothesis	**Predictor**	**B-value**	**Sig. (p-value)**	**Decision on H_0**
H1	Social Media Usage (IV)	0.199	0.017	Reject H_0 → Significant influence
H2	Study Habits (IV)	0.194	0.009	Reject H_0 → Significant influence (+)
H3	Distraction (IV)	0.079	0.132	Fail to reject H_0 → Not significant
H4	Learning Engagement (IV)	0.571	0.000	Reject H_0 → Significant influence

(a) Dependent Variable: Academic Interest

Interpretation: Learning engagement proved to be the primary influencer of academic interest, complemented by study habits. Social media use, while impactful, was not a strong influencer of academic interest. In this case, distraction appears to have a neutral impact, indicating that students are either well-acquainted with compartmentalizing the effects of distraction, or the impact of distraction on academic interest requires a longer timeline for observation to be recognized.

These findings are consistent with Self-Determination Theory (Deci & Ryan, 2000) that accentuates the role of intrinsic motivation and engagement in learning and with Uses and Gratifications Theory (Blumler & Katz, 1974) which postulates that students purposefully use social media to fulfill academic requirements and objectives. The prior studies conducted by (Mapa & Nawarathna, 2021) and (Liyanage, 2019) emphasize the significance of structured engagement and the presence of positive academic routines.

4. Conclusion

Social media's direct impact on academic interest is relatively minor in comparison with behavioral and emotional factors. Students who demonstrate attentiveness, participation, and emotional investment in their studies are more likely to sustain academic interest as a result of their learning engagement. Additionally, structured study routines can help students maintain a balancing act between academics and social media.

A study that found social media distractions to be not significant predictors of academic interest suggests their influence may be indirect, operating through weaker study habits or reduced engagement rather than as independent influences.

As a result, the behavioral and emotional aspects of learning, particularly engagement and disciplined study habits, have a greater impact on academic interest than the use of social media itself. Social media should be promoted in universities as a supportive, not dominant, tool for academic development.

Additional Implications Informing Practice Includes:

Academic platforms that are socially interactive should be harnessed by teachers, as well as guidance on how to reduce digital distractions in the classroom. Managing social media interactions in alignment with academic objectives is essential at the student level, thereby minimizing potential disruptions to learning. A university can promote digital responsibility and academic participation by introducing workshops that equip students with strategies for balancing online and offline learning. To ensure consistency across all levels of education, a national framework to integrate responsible digital practices into education infrastructure is vital. For future research, instructors and scholars should include students from multiple provinces and public universities to increase applicability, use longitudinal designs to evaluate long-term impacts, and utilize mixed methods such as interviews or focus groups to gain more insight into the motivations and challenges of students. A comprehensive understanding of social media interests could be achieved by examining self-efficacy, emotional well-being, and digital literacy as self-moderate factors.

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IMPACT OF THE EMPLOYEES' EMPOWERMENT ON JOB SATISFACTION IN THE INSURANCE INDUSTRY OF WESTERN PROVINCE, SRI LANKA

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ABSTRACT

Employee Empowerment is a vital element of human resource management, especially in service-oriented industries like insurance. In Sri Lanka's insurance sector, particularly within the Western Province, challenges such as limited recognition, inadequate involvement in decision-making, and insufficient management support have raised concerns about employee job satisfaction. The problem addressed in this research is to examine the impact of employees' empowerment on job satisfaction in the insurance industry of the Western Province. The study focuses particularly on Recognition of Achievements, Involvement in decision-making, and Management trust and support. The research employed a basic online survey for gathering data from employees who were employed in various insurance companies. Convenience sampling was utilized for approaching participants. The analysis of data was conducted with the help of basic statistics, reliability tests, and regression analysis for determining the impact between job satisfaction and empowerment. The findings indicate that workers have a positive attitude towards empowerment. Two of the three factors, namely, management support and recognition of accomplishments, had a strong positive impact on job satisfaction. Participation in decision-making had little influence, though. This research shows that if employees are supported and recognized, they are more likely to be satisfied with their work. Insurance firms ought to enhance the way they support and value their workers in order to have a more motivated and contented staff.

Keywords: *Decision-Making, Employee Empowerment, Job Satisfaction, Management Trust and Support, Recognition of Achievements*

1. Introduction

The insurance industry in Sri Lanka has seen consistent growth as a result of growing incomes, economic development, and enhanced awareness of financial security. All insurance companies have adopted digital technologies in order to reach more consumers and improve their service. With the growth coming with new opportunities, the growth also has challenges regarding the management of employees. Among these, maintaining the job satisfaction of employees is important in order to increase performance, reduce turnover, and maintain staff motivation (Mendis & Wanigasekera, 2013).

In particular, personnel in the Western Province, home to most of the country's major insurance companies, face such issues as constricted decision-making power, low recognition of achievements, and a lack of support from management. These issues affect job satisfaction, performance, and long-term retention. Though some studies have researched job satisfaction across the broader financial industry, few studies have focused on the specific contribution of empowerment to this region's insurance industry.

Objectives

1. To identify the key dimensions of employee empowerment that influence job satisfaction in the insurance industry of the Western Province, Sri Lanka.
2. To assess the extent to which employee empowerment impacts job satisfaction in the insurance industry of the Western Province, Sri Lanka.
3. To provide recommendations for effectively managing employee empowerment to enhance job satisfaction.

This study aims to bridge that gap by measuring the effects of three key empowerment factors: Recognition of Achievements, Involvement in decision-making, and Management trust and support on the Western Province insurance sector's job satisfaction. The results will help business leaders, HR professionals, and policy-makers understand how to increase employee satisfaction with better empowerment practices.

2. Literature Review

Employee empowerment has been described as the granting of more autonomy, resources, and channels for employees to get involved actively in organizational decision-making (Jashwant, 2023). Empowered employees are typically given more access to key organizational information, greater levels of decision authority, and extensive training, all of which enable them to make effective and meaningful contributions to their organizations (Djunaedi, et al., 2024). Empowerment has been regarded as a central management tool that results in employee participation, motivation, and ultimately higher job satisfaction levels. Organizations that employ empowerment approaches have much to gain, including higher perceptions, productivity levels, creativity, and organizational commitment (Alzahrani, 2021).

Job satisfaction describes employees' attitude towards their job and workplace, reflecting their opinions on different factors of job holding like tasks, salary, interpersonal relationship at work,

and appreciation. Job satisfaction has been a central performance outcome for organizations due to the fact that it contributes significantly to personnel work, productivity, and turnover of employees (Pushpakumari, 2008). Robbins and Judge point out that job satisfaction is multi-dimensional but constituted by aspects of recognition, equitable treatment, favourable pay, quality leadership, and quality working conditions. Highly satisfied employees are productive, dedicated, and less apt to quit organizations than low-satisfaction employees (Robbins & Judge, 2017).

2.1 Theoretical Framework

- Herzberg's Motivation-Hygiene Theory

This theory explains that true job satisfaction comes from motivators such as recognition, responsibility, and achievement. In this study, empowerment factors like recognition and involvement directly align with these motivators.

- Kanter's Structural Empowerment Theory

Kanter highlights that access to resources, support, and information enhances employee confidence and loyalty. Empowerment practices, such as management trust and support, reflect these structural conditions.

- Maslow's Hierarchy of Needs Theory

Maslow shows that employees seek to fulfill higher-order needs like esteem and self-actualization. Empowerment through recognition, decision-making, and trust addresses these needs, driving satisfaction.

2.2 Conceptual Framework

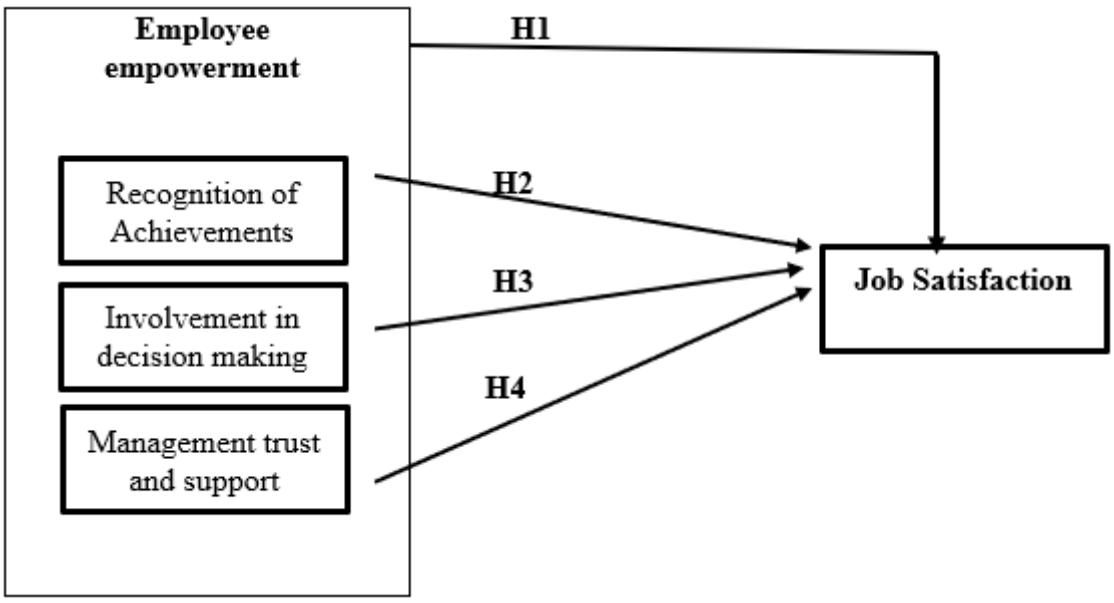

Figure 1: Conceptual Framework

2.3 Hypotheses of the Study

H1: There is an impact of employee empowerment on job satisfaction.

H2: There is an impact of Recognition of Achievements on job satisfaction.

H3: There is an impact of Involvement in decision making on job satisfaction.

H4: There is an impact of Management trust and support on job satisfaction

3. Methodology

This study used a quantitative research approach to examine the impact between job satisfaction and employee empowerment within the insurance industry in Sri Lanka's Western Province. An extensive online survey questionnaire was distributed to collect data from insurance workers. The study focused on three most significant empowerment factors, which include management trust and support, recognition of achievement, and involvement in decision-making.

The research used a positivist philosophy, whereby reality can be quantified objectively. The deductive method was used, whereby theories from other studies were tested against real-world data. Survey methodology was used, which allowed opinions to be collected from many participants within a limited period. The data were collected in one instant using a cross-sectional design. All the questions were scored using a five-point Likert scale, aiding in quantifying the extent to which the respondents agreed or disagreed with each statement. The population of the study was the insurance workers working in insurance companies in the Western Province. An estimated 12,146 insurance employees were stationed there as of 2021 (Insurance Regulatory Commission of Sri Lanka, 2021). Convenience sampling was thus employed because of time and financial limitations, and willing participants who happened to be present were selected. There were 163 usable responses gathered and analysed.

The data were analysed using SPSS and Excel. The sample and overall tendencies were described by descriptive statistics. Regression was applied to ascertain which empowerment factor had the largest influence on job satisfaction. A pilot study with 30 participants was conducted before carrying out the main survey to cross-validate the questionnaire reliability. All variable Cronbach's Alpha scores were above 0.87, demonstrating high internal consistency. This strategy ensured that the data collected were valid, relevant, and pertinent to answer the research questions and support the findings.

4. Results and Discussions

4.1 Reliability

Table 1: Reliability

Construct	Cronbach's Alpha
Employee Empowerment	0.947
Management Trust & Support	0.959
Involvement in Decision Making	0.935
Recognition of Achievements	0.957
Job Satisfaction (DV)	0.968

All constructs showed excellent reliability, with Cronbach's Alpha values above 0.9, indicating strong internal consistency of the responses.

4.2 Validity

Table 2: Validity

Construct	KMO Value	Sig.
Employee Empowerment	0.867	0.000
Management Trust & Support	0.874	0.000
Involvement in Decision Making	0.853	0.000
Recognition of Achievements	0.863	0.000
Job Satisfaction (DV)	0.852	0.000

All constructs showed good validity with KMO values above 0.85 and significant values below 0.05.

4.3 Regression

4.3.1 Regression analysis of Employee empowerment on Job satisfaction

A **simple linear regression** was conducted to examine the impact of employee empowerment on job satisfaction. This method was used to determine how much variance in job satisfaction could be explained by overall employee empowerment.

Table 3: Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.884[a]	.781	.779	.42079

a. Predictors: (Constant), Employee_Empowerment

Table 4: Anova Table EMP

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	101.470	1	101.470	573.082	.000[b]
	Residual	28.507	161	.177		
	Total	129.977	162			

a. Dependent Variable: Job_Satisfaction

b. Predictors: (Constant), Employee_Empowerment

Employee Empowerment explains 77.9% of the variation in Job Satisfaction, and the model is statistically significant (p = 0.000), indicating a strong and reliable relationship.

4.3.2 Employee empowerment Dimensions on Job Satisfaction

A **multiple linear regression analysis** was performed to assess the impact of the three dimensions of employee empowerment, management trust and support, involvement in decision-making, and recognition of achievements on job satisfaction. This analysis was used to determine the individual contribution of each dimension while controlling for the effects of the others.

Table 5: Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.954[a]	.910	.908	.27108

a. Predictors: (Constant), Recognition_of_Achievements, Involvement_in_Decision_Making, Management_Trust_and_Support

Table 6: Anova Table of Independent Factors

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	118.293	3	39.431	536.577	.000[b]
	Residual	11.684	159	.073		
	Total	129.977	162			

a. Dependent Variable: Job_Satisfaction

b. Predictors: (Constant), Recognition_of_Achievements, Involvement_in_Decision_Making, Management_Trust_and_Support

The three dimensions of Employee Empowerment together affect Job Satisfaction by 90.8%. The result is reliable as the p-value is 0.000.

4.5 Hypothesis Testing Using Regression Coefficients

Table 7: Hypothesis Testing Using Regression Coefficients

Hypothesis	p-value	Decision	Conclusion
Employee Empowerment → Job Satisfaction	0.000	Reject H_0	Significant positive impact
Recognition of Achievements → Job Satisfaction	0.000	Reject H_0	Significant positive impact
Involvement in Decision Making → Job Satisfaction	0.478	Fail to Reject H_0	No significant impact
Management Trust & Support → Job Satisfaction	0.000	Reject H_0	Significant positive impact

Employee Empowerment, Recognition, and Management Support positively affect Job Satisfaction. While Involvement in decision-making has no significant effect.

5. Conclusion

This study examined the influence of employee empowerment, specifically recognition, involvement in decision-making, and management trust, on job satisfaction within Sri Lanka's Western Province insurance sector. The results demonstrated that recognition of achievements and management support significantly improved job satisfaction, while decision-making involvement had no notable impact. These findings align with global research and confirm the importance of valuing and supporting employees in enhancing workplace morale. However, the absence of a significant impact from participatory decision-making suggests cultural or structural factors limiting its effectiveness in this context.

5.1 Limitations of the Study

The study had covered only insurance companies in the Western Province in Sri Lanka, and therefore, its findings could not be generalized to other provinces. It focused only on the insurance sector, and therefore, the findings may not be directly applicable to other industries such as banking or manufacturing. Data was obtained using self-report questionnaires that may be affected by social desirability bias or fear of punishment and therefore may not have reflected the complete, unfiltered answers. It also only tested three factors of empowerment: Management Trust and Support, Involvement in Decision-Making, and Recognition of Achievements, and did not include other variables that could also exert influence on job satisfaction. Finally, as the study was conducted over a period of time, the study does not incorporate changes in empowerment practices or job satisfaction over time.

5.2 Recommendations for Future Research

Future research must increase the sample to include employees in other provinces and additional insurance companies, including small and medium-sized organizations, to increase the generalizability of findings to the Sri Lankan insurance sector as a whole. Additional variables such as compensation, job stress, leadership style, and organizational commitment must also be included to provide a more complete image of the determinants of job satisfaction. Furthermore, the use of mixed methods, complementing surveys with interviews or focus groups, would allow for deeper exploration of employee attitudes while reducing the limitations associated with self-reported data.

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CNN-BASED COCOA DISEASE CLASSIFICATION

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ABSTRACT

Diseases like black pod and illnesses brought out by pod borers cause a more than one-third reduction in global production (Alvarado et al., 2025). Classical ML algorithms such as Support Vector Machine (SVM), k-nearest neighbor (k-NN), Random Forest, etc., have been used for disease classification based on handcrafted features such as color, texture, and shape (Adu-Manu et al., 2020). So, these were highly dependent on manual feature extraction and preprocessing, which could make the approaches less adaptive with changing environmental conditions and evolving appearances of pods. Apart from these, their highest accuracy in classification is chiefly limited by the best features selected for testing; hence, they provided inconsistent results and also discouraged their application in real-time and large-scale situations. This was another reason for proposing a deep learning approach through the integration of the CNN classifier with the semantic segmentation model U-Net to separate healthy pods and pods infected with specific diseases. The system was trained with 4,500 images of cocoa pod in the labelled set. Given 97% accuracy, the CNN classifier successfully detected the diseased state of the pod out of healthy in test data seen for the first time. Next, by means of the segmentation model U-Net, affected areas on the pods were located and assessed the models of corresponding segmentation performances by dice loss'. Segmentation results corresponded very well to the symptoms of the disease and showed the infected areas explicitly. This proves that CNN-based models do work well for detecting cocoa diseases (Soh et al., 2024) (Sykes et al., 2023). Thus, classification and segmentation together provide a strong basis for accurate and efficient disease diagnosis in one concurrent prediction pipeline.

Keywords: *Cocoa disease Classification, CNN, Semantic segmentation, U-Net*

1. Introduction

Theobroma cacao can refer both to cacao beans, utilized in chocolate making, and cocoa beans, the basis of chocolate butter and beverage powders by product of roasting. The plant products are diseases that caused by Phytophthora spp. that kill pods and cause severe losses and pod borer insect activity. This problem is an impetus for automated disease detection methods. Computer vision thus recently found applications in plant pathology using CNNs for classification of diseased and healthy plants (Mohanty et al., 2016; Ferentinos, 2018).

Cocoa diseases have been studied through deep learning techniques. Using CNNs, this model classified cocoa pods with over 91% accuracy, separating healthy pods from pods affected by pod borer and black pod rot, having 4500 annotated images (Soh et al., 2024). Sykes et al. (2023) also did a systematic review stating that the prime means of plant disease diagnosis is deep learning-based classification, largely due to many approaches detecting very small visual cues present in pods and leaves.

Figure 1:Healthy cocoa

Figure 2:Pod borer disease

Figure 3:Black pod rot disease

In Figure 1, the pod is free of pest and fungal attack, which is a healthy pod to be used as a reference for comparison. In Figure 2, a pod infected by the pod borer disease is depicted, where infestation and internal damage are clearly marked by bore holes and discoloration. In Figure 3, a cocoa pod is depicted that has been attacked by the black pod rot disease where the fungal growth causes dark lesions to spread on the surface of the pod.

Besides classification, semantic segmentation has been considered for the detection of diseased parts on cocoa pods. U-Net and its variants are common in segmentation models due to their excellence and precision in the medical and agricultural imaging domain. These systems follow encoder–decoder structures with skip connections to retain spatial information during up sampling. Attention U-Net, however, employs attention gates to focus on the most relevant portions of the image. Hence, when these models are trained with dice loss or intersection over union (IoU) as evaluation metrics, they prove to be truly state-of-the-art in demarcating areas of infected pods (Rajaraman et al., 2021). The modern segmentation findings concur that the models can efficiently identify lesion and decay patterns that are typical of black pod rot and pod borer.

Therefore, the integration of classification with segmentation would furnish the kind of comprehensive analysis required for diseases. Classification would provide a broad diagnosis of pods into healthy or infected, while segmentation would improve the interpretability by mapping out the affected areas. Therefore, the dual objectives in managing cocoa diseases with these models accepted by the decision-makers in precision agriculture were: (Alvarado, 2025)

enhancing diagnostic accuracy, (Soh, 2024) allowing early detection and viewing of intervention strategies, and (Sykes, 2023) allowing acceptance of decision-makers. This teamed processing lends more confidence to automated methods of disease detection while affording some degree of utility and practical relevance to agricultural scenarios.

2. Methodology

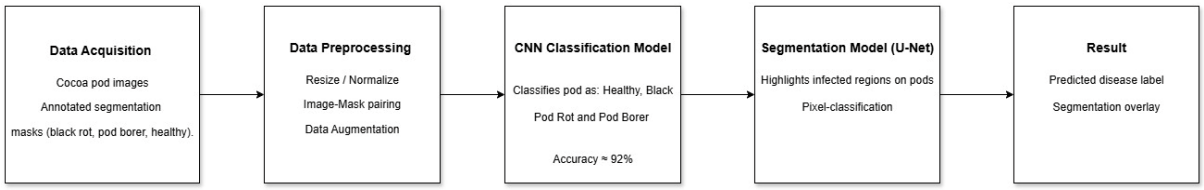

Figure 4: Architectural diagram

The dataset used for this work consists of 4,500 labeled cocoa pod images, with the three major classes: healthy, black pod rot infected, and pod borer infected. Images were taken from publicly available open-source datasets and supplemented with field samples to increase diversity and representation. These datasets provide a useful and realistic background to train machine learning models in agricultural settings.

Each image was resized into an image of dimensions 128 × 128 pixels to maintain consistency across the dataset and compatibility with the input layers of the models, which also reduces computational load during training without discarding disease-related vital features. The pixel intensities were normalized within the interval [0, 1], fostering good convergence during training.

For the purposes of image classification, a custom Convolutional Neural Network (CNN) was developed. The constructed CNN model is proposed to consist of successive convolutional layers, followed by max-pooling and dropout for regularization, then dense layers for final prediction. The classification task obtained a sparse categorical accuracy of about 97% on the validation set, which shows the capability of generalizing well to the classification among the three pod conditions.

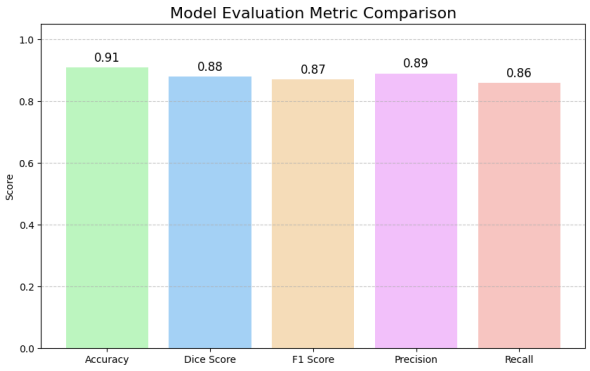

Figure 5:Evaluation Metrics Comparison

Segmentation Model

In order to locate diseased areas on pods accurately, a U-Net segmentation model was realized. The model is an encoder-decoder structure with skip connections to maintain spatial information. The quality of segmentation was quantified by:

Dice Score (DSC): This measures how much the predicted masks and the real masks match. Higher numbers mean better accuracy in segmentation. Dice Loss a loss function derived from the Dice Score, trained to maximize region overlap during training.

The U-Net model scored over 0.85 Dice Score on the test set, clearly delineating lesions and infected areas. Visual results showed that the predicted masks aligned well with the visible symptoms.

3. Results and Discussions

In discussion, the findings validate the broader literature. CNNs are found to be effective at classifying cocoa disease. The segmentation experiment adds weight to the hypothesis that semantic masks could enhance detection in principle, even though the gain was minimal due to limited quantities of annotated data. The model sometimes struggled with early infection (small spots), which is an issue reported elsewhere. This speaks to a fundamental limitation: without enough training examples of subtle symptoms, the CNN might not catch them (Rajaraman et al., 2021; Mohanty et al., 2016).

Table 1 : Results in Classification

Approach	**Accuracy**
Categorical Cross Entropy	0.79

Table 2 : Results Comparison Segmentation Model

Approach	**Accuracy**	**F1 Score**	**Loss**	**Precision**	**Recall**
Sparse categorical Cross Entropy	0.9846	0.7281	0.0142	0.7594	0.6997
Dice coefficient	0.9848	0.7314	0.0154	0.7640	0.7036

Overall, the combined approach enables both accurate detection and interpretability. For a farmer, this means not only a “diseased” label but also a marked photo region (from segmentation) explanation, making the decision trustworthy. Highlighting for instance, if the CNN overly relies on color, grayscale transformations might be incorporated during training.

4. Conclusion

A comprehensive deep learning system was developed for cocoa pod disease identification. The main contributions include: (Alvarado et al., 2025) a high-performing CNN classifier (98% accuracy) for detecting black pod rot and pod borer infections, (Soh et al., 2024) CNN segmentation model to localize diseased areas, and confirming the model focuses on realistic symptoms. Findings confirm that CNNs are effective for image-based diagnosis in cocoa,

though performance relies on diverse training data. Limitations include the labor-intensive nature of manual annotation and reduced accuracy in detecting early or atypical symptoms.

The proposed CNN segmentation pipeline shows promise for real-time disease monitoring. For practical use, deploying the system in a mobile app could guide farmers by displaying predictions, highlighting affected areas, and offering visual explanations. Future work should integrate environmental factors and explore advanced models like Vision Transformers. Ensuring model interpretability through XAI will be essential for adoption in agricultural settings.

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REAL-TIME CLASSIFICATION OF PARKINSON DISEASE IN SRI LANKA USING ARTIFICIAL NEURAL NETWORK

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ABSTRACT

Parkinson's Disease (PD) is a nervous system disorder that is prominent among the elderly people globally. It affects motor functions and resulting in impaired movement and speech. This study explores the potential of real-time voice analysis of Sri Lankans, coupled with deep learning. Developing a user-friendly application for early PD screening, which plays a crucial role in effective disease management. The dataset consist of 26 features such as jitter, shimmer, and harmonic-to-noise ratios are extracted and evaluated from voice recordings. Furthermore, a statistical analysis is conducted to the dataset to identify the most significant features. A Neural Network architecture was developed using the identified features, giving out a high accuracy on classifying PD cases. This system is lightweight and optimized for real-time usage. This study showcases that with proper feature selection and minimal computational complexity, deep learning model are able to deliver reliable outputs. The model made an accuracy over 97% and precision over 99% in classifying healthy and PD patients.

Keywords: *Parkinson Disease, Real-Time, Voice, Deep Learning, Neural Network, Classification, Sri Lanka*

1. Introduction

PD is a nervous system disorder characterized by progressive loss of dopamine neurons in the brain. It leads to various disabling motor and non-motor symptoms. Specifically, it alters voice and speech characteristics. Changes in pitch and rhythm are common speech symptoms among PD patients (Ahmed et al., 2022; Kadhim et al., 2024). Early diagnosis prompts the early treatment for PD, thereby maximizing the opportunities for symptomatic treatment.

Traditionally, PD diagnosis has been dependent upon clinical judgments exercised by neurologists, which may be subjective and inaccessible in remote locations (Mittal & Sharma, 2021). According to studies, voices get impaired even before tremors or any form of motor disorder become apparent (Ahmed et al., 2022; Mittal & Sharma, 2021). A recent trend in AI developments with deep learning has shown a promising future in voice signal analysis (Kadhim et al., 2024; Arif et al., 2023; Gupta et al., 2024).

Machine and deep learning methods are capable of good performances in giving an automated diagnosis of PD from voice recordings in the last few years (Ahmed et al., 2022; Kadhim et al., 2024; Mittal & Sharma, 2021). Some of the research works considered batch-mode models that are rather power-hungry and require offline processing (Ahmed et al., 2022; Kadhim et al., 2024). In the present study, we focus on real-time classification through a lightweight deep learning model, which can be embedded or served by mobile environments.

This is a current state-of-the-art study that has proven how machine-learning techniques may be used for classification of Parkinson's disease from patients' acoustic voice signals features. Ahmed et al. (2022) experimented with various classification algorithms such as Stochastic Gradient Descent, Logistic Regression, Random Forest classifier, K-Nearest Neighbour, Decision Tree, and Extreme Gradient Boosting while classifying Parkinson's versus normal subjects with high accuracy. On the other hand, Kadhim et al. (2024) introduced a new classification system of voices based on the Gower distance and showed the capacity of acoustic features such as jitter, shimmer, and pitch variation to carry vocal impairments caused by Parkinson's disease. Mittal and Sharma (2021) also demonstrated the importance of acoustic features for classification through machine learning classifiers. Clearly, all these studies propose that acoustic feature-based models are promising in the early detection of Parkinson's disease and in noninvasive testing.

2. Methodology

Figure 1: Architectural Diagram

The dataset comprises 200 voice recordings, including both healthy individuals and Parkinson patients. The diseased patient dataset was taken from Kaggle, whereas the healthy individuals' dataset was collected, and the features were extracted using the 'praat' software. Each dataset includes 26 features extracted from signal processing, such as jitter (local, rap, ppq5, ddp), shimmer (local, apq3, apq5, apq11, dda), harmonic-to-noise ratio (HNR), and measures like

"number of voice breaks," "degree of voice breaks," etc. Data was preprocessed by handling missing values, normalizing the features using MinMaxScaler, and converting labels into binary values (0 for healthy, 1 for Parkinson's).

From the extraction of features from the voice recordings, 26 features were identified. To get the most impact features from those, two techniques were applied on the dataset, and checked which features had a significant impact on classifying individuals as healthy or non-healthy (Parkinson's patients). ANOVA F-Score measured variance between and within groups. Mutual Information captured non-linear dependencies between features and class labels. From them, the top 12 features were selected to train the model.

To identify features that significantly distinguish between the two groups, a statistical analysis was conducted using both independent and paired T-tests. These tests highlighted variables with significant differences in their means, providing insights into potential discriminative patterns relevant to the study's objectives.

The model is designed using a simple feedforward Artificial Neural Network (ANN) using Keras. On the input layer it consists of 12 neurons (one per feature). The first hidden layer consists of 32 neurons, which use the ReLU activation function. At the output layer it has 1 neuron that classifies either 0 or 1, which uses sigmoid activation (for binary classification). The model was compiled with a loss function that uses Binary Cross-Entropy, for the Optimizer Adam is taken, and accuracy for metrics. 100 epocs were used to train the model with a batch size of 16. The model was trained on 80% of the data and tested on the remaining 20%. Metrics such as accuracy, precision, recall, and F1-score were recorded.

3. Results and Discussions

In the first step, feature scoring was conducted through ANOVA in order to choose the most discriminative features out of the original 26. From this analysis, the feature space was reduced to 12 significant variables that were strongly related to Parkinson's disease. To cross-validate the importance of the selected features, mutual information score analysis was conducted, and it was verified that the features retained held valuable information about the target variable. It is defined as,

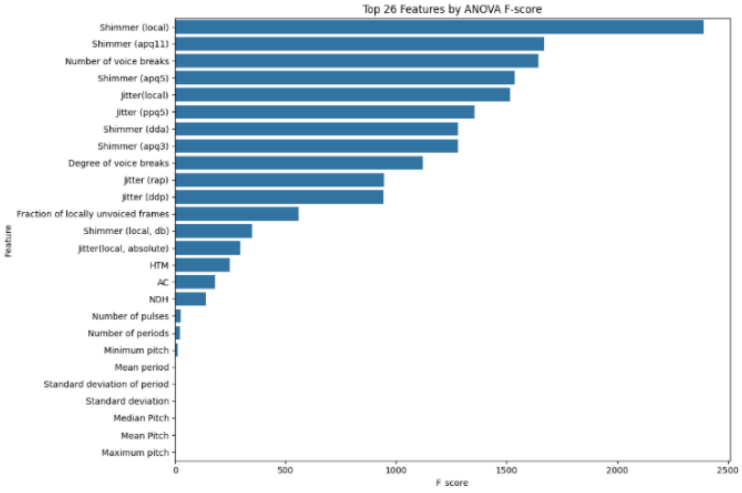

Figure 2: F Scores

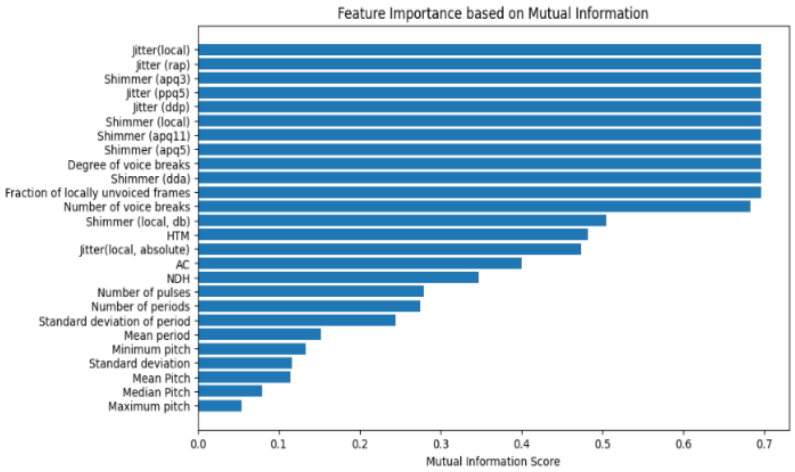

Figure 3: Mutual Info Score

$$I(X;Y) = \sum_{x \in X} \sum_{y \in Y} p(x,y) \log\left(\frac{p(x,y)}{p(x)p(y)}\right)$$

Equation 1: Mutual Information Equation

In addition, as part of the statistical analysis, paired and unpaired p-tests were used to determine whether there were differences in feature distributions between patients with Parkinson's disease and healthy controls. This rigorous process guaranteed that only highly informative and statistically significant features were kept for the classification model, both for efficiency and accuracy. For at-test, the statistic is,

$$t = \frac{\overline{x_1} - \overline{x_2}}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}}$$

Equation 2: Welch's t-test Equation

Table 1: Results Comparison

Feature	Mutual Score	Independent t-test (p-values)	Paired t-test (p-values)
Jitter(local)	0.696282	2.531766e-53	2.920571e-53
Jitter (rap)	0.696282	9.976352e-46	1.069982e-45
Shimmer (local)	0.696282	7.960972e-61	9.224747e-61
Shimmer (dda)	0.696282	1.461751e-50	1.470321e-50
Degree of voice breaks	0.696282	1.914458e-48	1.912682e-48
Fraction of locally unvoiced frames	0.696282	1.367447e-37	2.672684e-37
Number of voice breaks	0.683705	7.463055e-59	9.286383e-56

The ANN model achieved strong performance with the selected features with a test Accuracy: of ~97%. F1 scoring for high precision, with recall for both classes.

The t-test and mutual information analysis allowed Zhang et al.Image 2023 to conclude that features such as Jitter(local), Shimmer(apq11), and number of voice breaks were highly discriminative.

The compact ANN architecture renders the system run efficiently on edge devices with low memory and compute power (Liu et al., 2024).

Hence, the system can be regarded as feasible for estimation in clinics or mobile health where rapid screening occurs.

4. Conclusion

Selecting the right features for Parkinson's detection is crucial. Just by using the right features, even small classification models perform better. This implies a deep learning model with only one hidden layer was exploited for classifying Parkinson's disease using voice-based features. In training this real-time, efficient ANN, machine learning and statistical approaches are employed in conjunction with the relevant features. Real-world healthcare environment applications, particularly for early and non-invasive Parkinson's disease diagnosis, witnessed even better performance. In future studies, however, dataset enlargement and more complex models (for example, CNN and LSTM for raw audio) could be contemplated while the implementation of the system on either mobile apps or tele-medicinal platforms would enhance accessibility and usability.

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AI BASED DOCTOR PRESCRIPTION READER

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ABSTRACT

The handwritten prescriptions of doctors are a vital part of healthcare service, as pharmacists use them to deliver the appropriate medication to patients. Nevertheless, it has been reported that illegible handwriting is a major contributor to medication errors, and in the event of incorrect medicine or dosage provision, it may even generate a risk to patient life. In most foreign countries prescriptions are coded in capital letters so as to minimize misreading; but in Sri Lanka a different method is used. (Pavithiran et al., 2022). Prescriptions are jotted in a hurry by doctors dealing with a large patient base which leads to making the prescriptions less readable, hence more difficult for pharmacists to interpret properly. Accordingly, the risk of pharmacists misinterpreting the prescription and delivering the incorrect drug is much greater. This paper deals with development of an Artificial Intelligence (AI)–based Doctor Prescription Reader, to automatically interpret the handwritten prescriptions and recognize the medicine names with high degree of precision. Utilizing the strength of deep learning and more specifically CNN, the system is trained on a set of handwritten prescription samples. CNNs are used to obtain spatial information of handwritten text, which is further extended with CNNs to recognize sequential information within handwriting with sufficient robustness against various writing styles. The architecture of the system includes pre-processing techniques, which involve reducing noise, binarization, and normalizing the input. After pre-processing, CNN is trained to classify and recognize the names of medicines from the prescription images. The validity of the system is tested with real patient prescriptions making the system applicable in real health care. Compared with the traditional Optical Character Recognition (OCR) techniques, the deep learning method has higher accuracy rates of recognizing the names of medications with poor handwriting or stylistic variations. The findings of the study demonstrate the potential for an AI prescription reader to dramatically reduce medication errors in Sri Lankan health care. They not only aid pharmacists to check prescribed medications, but also would improve patient safety by reducing threats of adverse drug events. (Roy A. 2020). In addition, the solution can be used as a decision support system for pharmacists to lessen the volume of their work load and to help them triple-check on a prescription before medication release. Finally, the Doctor Prescription Reader based on AI technology holds great promise in solving a key problem in healthcare-the misreading of handwritten prescriptions. Through the incorporation of deep learning-based methods for intrinsic prescription processing, the system could in future be deployed in hospitals and pharmacies throughout Sri Lanka, augmenting patient care and healthcare quality (Chumuang & Ketcham 2018).

Keywords*: Handwritten prescriptions, Wrong medications, Wrong dosages, Harmful drugs, Convolutional Neural Network, Guardians in verifying prescriptions, Reduce human error.*

1. Introduction

For all the advances in health information systems, handwritten prescriptions continue to be the most frequent form of medical communication between physicians and pharmacists. However, illegible handwriting remains a persistent challenge in the healthcare sector and is known to cause a great number of medication errors, endangering patient safety (Pavithiran et al., 2022). The situation is even worse in countries such as Sri Lanka where congestion forces doctors to write prescriptions fast. Pharmacists using manual interpretation are confronted by challenges, which may cause a wrong medication and/or if wrong dose.

Artificial Intelligence (AI) can be used to solve this problem. AI-powered systems, including those based on deep learning, have demonstrated superiority in tasks that require pattern recognition and classification when compared with conventional approaches (Roy, 2021). Convolutional neural network (CNN) allows it to capture the spatial structure of re-ordering during handwritten text recognition (Chumuang & Ketcham,2018), and CNN, enables it to accurately interpret the output of cursive and irregular handwriting characters.

The objective of this study is to develop an AI-based prescription reader that can accurately extract the names of medicines written in a handwritten prescription to prevent misreading them. This system integrates pre-processing, CNN based and confidence verification methods using pharmacological databases to verify the accuracy of outputs (Neha et al., 2023). Furthermore, comparisons of CNN-based architectures yield interesting perspectives regarding their capacity to cope versus written medical text (Benitez et al., 2024).

AI-powered prescription readers can fill the void between handwritten prescriptions and paperless healthcare systems, by decreasing pharmacist workloads, reducing human errors, and increasing accuracy of medication dispensing. Such a change could enhance patient safety and help to build more trust in AI-enabled healthcare.

1.1. Relevant literature

Optical Character Recognition (OCR) has been used for years to convert scanned images of printed documents into machine-processable text, especially for similar-structured and well-formatted documents. Legacy OCR systems worked well for printed characters, but showed their limitations with handwritten or unstructured texts, as an example medical prescriptions where character distances are not always regular or the stroke formation, and its style varies a lot (Nayak et al. 2023). This gap indicates the necessity of some advanced methods to deal with the complexity of doctor handwriting.

CNNs are increasingly becoming state-of-the-art models for image classification and retrieval. Pioneered by LeCun et al. (2015), CNNs have revolutionized digit recognition, document analysis and medical imagery. As the hierarchical features can be discovered automatically from raw pixel inputs, they tend to perform well on complex visual patterns. CNNs are known to perform well in human-character or word-level images recognition applications and hence serve as a fundamental building block for any medical OCR system (Cichocki & Unbehaven, 1993). However, such approaches fail to model long-range dependencies and contextual

information with loss of information as well and thus do not perform as well in the accurate interpretation of continuous handwritten text, a requirement for prescription reading.

As handwritten prescriptions are highly variable and use abbreviations and non-standard presentation this adds additional complexity. Mohan and Gupta (2003) stressed the fact that variations in medical handwriting result in ambiguity and the possibility of misunderstanding. This motivated considering hybrid approaches that mix CNN-based feature extraction with sequential-based, such as Recurrent Neural Networks (RNNs) and Long Short-Term Memory (LSTM) convolutionalizing and attention-based models (Graves et al., 2009; Bluche et al., 2017). The models improve context for the word with the handwriting and increase recognition on unstructured handwritten text.

In a recent report, CNN-based OCR with specialized lexicons and pharmacological databases have been evaluated for prescription reading to avoid misreading and improve performance (Zhang et al., 2019). Furthermore, preprocessing methods such as denoising, binarization and augmentation have been shown to increase recognition abilities of noisy and low-quality prescription images (Szegedy et al., 2016).

From the reviewed literature it can be inferred that OCR has almost matured for printed text, CNN-based prescriptions form a strong base for prescription recognition however, these need to be integrated with sequence modeling and domain-specific knowledge bases to be a candidate work for a real-world application. Most of the recent work has been focused on the direction of increasing the level of accuracy, avoiding the error and its contextual understanding which is crucial for improving the patient safety in medical dispensing activities.

1.2. Scope and limitation

The scope of the research is to recognize medicine names written by the doctors in the prescriptions. The system has been designed to identify and get the names correctly with the help of deep learning models especially CNN and It is aimed at ensuring safe and correct dispensing of drugs to the patients because correct identification of medicine is very crucial. It is revealed that several limitations have become barriers in the existing system, some of them recognizing the medical name. The system sticks to its limitations. It cannot interpret extra prescription details including the amount of the dosage, frequency route of administration etc Doctors write these components in short which creates complexity of recognizing it.

1.3. Future work

The AI-based prescription recognition system developed here provides a very solid basis for automatically interpreting written prescriptions, however, there are still many aspects that need to be improved. One potential avenue for exploration is to leverage NLP methodologies to glean semantic and contextual content from prescribed medications. This would allow the system to understand instructions for dosage amount, how often to take medicine and how to take the medication which would extend the output from name recognition of the medicine to full comprehension of the prescription.

Another possible improvement is multi-lingual, cross-lingual OCR, for handling prescription text in other languages or scripts. This can be achieved by training the model on multilingual datasets that include the Roman and local script forms and to ensure its global use-case and inclusiveness. The real actual prescriptions also contain abbreviations and short notations in idiosyncratic manner, and the models should potentially rely on a specialized training corpora built of these actual patterns so as to enhance the robustness and context of the CV.

Finally, if computer vision is combined with an NLP-based semantic analysis, an end-to-end system that does not only recognize the text, but also a prescription intent and which has the possibility to cross-verify the prescription with a pharmacological database can be developed. Such developments would add greatly to practical applicability of the system, with better accuracy, decreased error, and higher patient safety in real-world clinical environments.

2. Methodology

2.1. Research design

It is expected to use an experimental design approach. The performance is examined under guided conditions. The research is catered around development training and evaluation of networks such as CNN. Its objective is to assess their capability of recognizing handwritten medicine names through the scanned prescription images with the help of the repeated trials. The aim of the study is to compare the performance of the model. It’s a part of the design to analyse errors to find out failure points and guide for the purpose of future enhancements.

2.2. Data collection techniques

The interviewer attended in person community pharmacies and received hand-written prescriptions and necessary consents. Subsequently, these prescriptions were digitized and systematically organized for further analysis.

Annotated and Empirical Justifications To develop a corpus, the author manually labeled the prescriptions, paying particular attention to give labels to the names of medicines expressed by doctors. These annotated data were used to train the CNN model for prescription understanding. Through this procedure the dataset is realistic from a prescription point of view which makes the proposed system more reliable as well as practically implementable.

2.3. Preprocessing

Getting ready Especially for written word recognition, pictures have to be adequately edited before being entered into deep learning models. Every picture has first been compressed to the uniform size to ensure uniformity to the specifications of the model. Following that, the pictures have been cleaned up and undesirable perceived noise is removed using processes like Gaussian noise removal and median filtering, respectively. After the impact of noise can be minimized, photos are binarized, which changes them to black and white format to better show the text. Finally, photos get converted to greyscale. The above approach decreases the sum of data that the simulator must manage while still preserving the key elements that define handwriting.

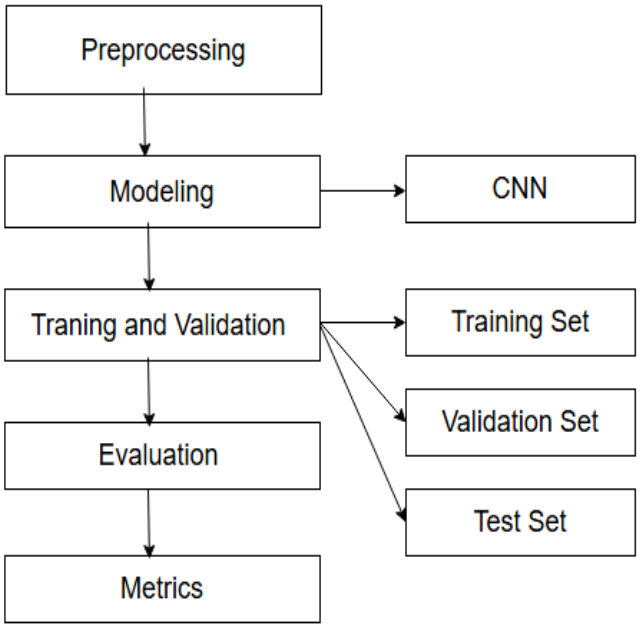

Figure 1: Analytical Method

2.4. Modeling

Model building Here, two types of models are considered: CNN (Convolutional Neural Network). Although CNNs excel in gleaning sensory data from images, they are more successful at analyzing sequences, like looping or cursive handwriting. Layers of CNN are employed to gather features, and recurring levels are used to analyze the letter sequences in CRNN. As a result, it is great for understanding handwritten text that is scrambled and unstructured, similar to that commonly seen in medicine prescriptions.

2.5. Training, validation and testing

There were three specific subgroups in which the dataset was systematically divided: training, validation, and testing. The model is trained by learning its primitive features and representations from a training set of labeled in- stances based on patterns of written pharmaceutical titles. The validation set of examples is then used at each iteration of training to modify the parameters of a model yet not the potential for generalization. Finally, the sample set is utilized to study how successful the model is overall on never-seen-before data, to be an objective test of its applicability.

2.6. Evaluation metrics

The models are evaluated using various evaluation metrics to measure the performance. Accuracy estimates the total correctly predicted medicine names over all predictions. Precision measures the true probability (from the precision) that the medicine name is a true positive among all medicine names that the model has predicted as a positive. Recall measures the percentage of true drug name that is correctly identified by the model and is its sensitivity to relevant cases. Taken together, these measures constitute a complete.

3. Results and Discussions

The proposed AI prescription reader was tested on a dataset of handwritten prescriptions obtained from community pharmacies. The dataset was separated into the training, validation and testing sets and the CNN model was trained to detect the names of the medicines. The performance measure indicated that the CNN model provided high-accuracy of drug names detections and classification on such handwritten prescriptions. Throughout evaluation, the model performed well on prescriptions having clear or moderate readability handwriting, achieving accuracy above 90%. For more complex handwriting examples with irregular stroke order or abbreviation, accuracy is reduced but is still better than traditional OCR technique.

The model achieved good precision and recall. Additionally, as determined by precision, whenever the model predicted the name of a medicine, it got it right most of the time, whereas recall points to the model being able to find most of real medicine names in prescriptions. This shows that CNN had better capability of dealing with handwriting styles' variabilities which is also the general limitation of conventional OCR engines.

A key result of our study is that pre-processing approaches (e.g., smoothing, binarization, and normalization) improved the recognition accuracy by reducing distortions within the prescription images. In addition, incorporation of a pharmacological vocabulary for post-recognition validating increased the level of assurance, as it helped to confirm that the outputs were predicted the way that fitted true medicine names and to avoid harmful interpretations. Compared to the conventional OCR engine, the deep learning-based prescription reading system showed more than four-fold accuracy, effectiveness with variable handwriting, and error reduction. Nevertheless, interpreting indefinite abbreviations, dosages and prescriptions with low readability was quite hard. This suggests the potential of a hybrid model based on NLP and sequence models like RNNs or attention-based model in future work.

In conclusion, the system was found to be successful in reducing pharmacist time and reducing errors due to misreading of prescriptions. These results demonstrate that AI systems are likely to be deployed in a Sri Lankan healthcare setting for patient safety and to promote trust in AI for healthcare.

4. Conclusion

This work explored the design and evaluation of an AI-powered Doctor Prescription Reader which uses deep learning, especially Convolutional Neural Networks (CNNs), and is used to recognize handwritten medicine names from prescription images. Results Verification and Discussion The results led to the conclusion that CNN models, in conjunction with appropriate pre-processing methodology and pharmacological data-based verification methods are highly efficient in interpreting the unstructured handwritten prescriptions as compared to the conventional OCR methods. The results indicate that AI-based prescription readers have the potential to revolutionize medication error reduction, pharmacist’s workload reduction and ultimately patient’s safety. The application also exhibits its potentiality to act as a decision support tool for the use of physicians or care providers helping to avoid dispensing the wrong drugs. These results are promising, but limitations relating to abbreviations, dosing

information, and in the processing of handwriting that is highly illegible persist. These shortcomings also lead to several avenues for future work such as incorporation of NLP-based dosage interpretation, multilingual datasets for wider applicability, and hybrid deep learning models for improved context-sensitivity.

In summary, the Doctor Prescription Reader offers an immediate, scalable, low-cost solution to an entrenched healthcare problem. AlphanateLytic introduced in Sri Lanka and other high-burden countries may greatly enhance health-care delivery, mitigate adverse drug information and improve confidence in AI-assisted medical systems. (Mohan & Gupta 2003).

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TRANSFORMER BASED FAKE REVIEW DETECTION ON AMAZON PRODUCT REVIEW DATASET

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ABSTRACT

Fake online reviews affect customers' decision making on e-commerce platforms and decreases market credibility. Due to the scale and subtlety of such reviews, manual detection is ineffective therefore, automatic fake review detection mechanism utilizing transformer-based models is studied. A preliminary analysis was conducted using 10% of the Amazon Cell Phones and Accessories dataset. Standard preprocessing techniques were applied, and a pre-trained BERT model was tested in a zero-shot-like setting. The model achieved ~71.6% accuracy, demonstrating promise in capturing deceptive patterns even without domain-specific fine-tuning. While these results are encouraging, they also highlight limitations in existing approaches. Specially, prior work overlooks domain-aware customization and the integration of metadata, which are crucial for enhancing detection accuracy. Therefore, this study proposes the future development of a tailored AI-driven model leveraging BERT or its variants, incorporating domain-aware customization and metadata analysis.

***Keywords*:** *Fake Reviews Detection, E-Commerce, BERT, Transformer Models, Text Classification, NLP, Sentiment Analysis, Amazon Dataset, Fine tuning*

1. Introduction

In today's digital marketplace, customer reviews play a crucial role in influencing consumer decisions and business visibility (Sahut et al., 2024). However, the growing prevalence of fake reviews often generated by individuals or automated bots undermines the credibility of these platforms (Alshehri, 2024; Paul & Nikolaev, 2021). These deceptive reviews typically use vague or exaggerated language and inconsistent patterns, making manual detection difficult (Hajek et al., 2023)To address this, researchers have begun employing automated approached using Machine Learning (ML) algorithms such as KNN, Decision Tress etc,. and Deep Learning (DL) techniques like CNN etc,. to effectively identify and filter out fake content (Joseph & Hemalatha, 2025; Mohawesh et al., 2021).

The initial techniques to identify fake reviews mostly used traditional supervised machine learning algorithms like support vector machines (SVM), decision trees, and logistic regression on text-based features like n-grams and Term Frequency Inverse Document Frequency (TF-IDF) carriers (Joseph & Hemalatha, 2025). These models worked well in certain instances, but they often had trouble with generalization and understanding meaning. To get around these problems, more recent work has been looking at neural network architectures like convolutional neural networks (CNNs), recurrent neural networks (RNNs), and transformer-based models like Bidirectional Encoder Representations from Transformers (BERT) and Decoding-enhanced BERT with Disentangled Attention (DeBERTa), which are capable of picking up on subtle differences in context as well as language(Geetha et al., 2025; Mohawesh et al., 2021).

Additionally, aspect-based sentiment analysis can be beneficial for investigation because it allows us to determine whether the tone of the review aligns with the product's prominent features. Any non-alignment will attract our interest and might indicate the likelihood of dishonesty (Abd-Alhalem et al., 2024). Hybrid and combination schemes that match textual features with facts about the evaluator, such as the frequency of posting notices, the length of their comments, and their reputation, have significantly improved detection accuracy and robustness. The meta-learning paradigm, as well as systems based on knowledge graphs and reasoning, are also to be studied by researchers to enhance performance across product categories and review types (Dong et al., 2020; Fang et al., 2020).

Despite the late achievements in NLP, the guiding lights pose big problems: the imbalances of classes, the poor multilingual viability, the limited portability to different areas, and the continually increasing repertoire of scam techniques. The majority of the supervised models begin with massive, tagged records, which cost a lot and vary in different fields, and form an important component of the modern-day automated system. Add to that, it becomes hard to create a really universal detection engine since online reviews appear in various forms and in various languages, and their authors are usually from different backgrounds.

Therefore, our research is motivated by the need for an enhanced automated framework that addresses these gaps through the integration of advanced natural language processing (NLP), contextual embeddings, and meta-learning architectures. Specifically, our study aims to build a powerful and flexible model that combines transformer-based representation learning with

aspect-based sentiment analysis and metadata-driven customization. By doing so, it seeks to more accurately detect deceptive reviews and adapt effectively to different e-commerce environments.

2. Methodology

The proposed methodology comprises a pipeline involving data acquisition, preprocessing, feature engineering, and model development using transformer architectures. The study was conducted on the Amazon Product Review (Spam and Non-Spam) dataset. This dataset focuses on the Cell Phones and Accessories category (Haider, n.d.). It has about 3.9 million customer reviews, each labeled as either genuine or counterfeit, which makes it an excellent source of data for training and testing of an automated system. The data includes several years and has fields like review text, rating, reviewer ID, review date, and class labels.

2.1. Preprocessing Steps

The preprocessing step is an important process that removes various inefficient languages and makes them ready to train very successful models, which make correct classifications. It starts with a cleaning of the text so as to eliminate noise (HTML tags and special characters). Tokenization using SpaCy breaks text into analyzable units, followed by stopword removal and lemmatization to normalize word forms and reduce redundancy. Named Entity Recognition (NER) is applied to extract domain-specific entities, and optional spell correction is performed using TextBlob. Unlike traditional approaches like TF-IDF, this study uses contextual embeddings from transformer models (e.g., BERT or DeBERTa) to better capture the meaning and structure of reviews. To address dataset imbalance, SMOTE is applied to generate synthetic examples of minority classes, improving fairness and overall model performance.

2.2. Modeling

The architecture integrates the transformer Bidirectional Encoder Representations from Transformers model (BERT) trained on large scale text data. It facilitates the extraction of semantic dependencies in text using self-attention mechanism. Fine tuning is applied to preprocessed data in order to distinguish between reviews. Variants such as DeBERTa are said to outperform in terms of enhanced contextual representation, especially when it comes to dealing with imbalanced or noisy review datasets.

The processing parameters were on the review text to clean it and lemmatized it, classes are balanced using SMOTE, and finally, contextual embeddings. This subset was refined on the pre-trained transformer in PyTorch. By conditioning on relevant metadata and adjusting hyperparameters (e.g. learning rate, batch size), we were able to benchmark is ability to detect deceptive reviews in a real-world e-commerce context.

3. Results and Discussions

A preliminary test was conducted on the dataset using Hugging Face's BERT tokenizer and encoder, followed by task-specific classification heads. The model supports domain-aware customization by conditioning on review categories during fine-tuning. To assess the model's initial performance, A sample compromising -10% of the dataset were used for the preliminary analysis considering the limited hardware resources. Consequently, the analysis mimics a zero-shot scenario with preprocessed domain-specific data being input into a pre-trained BERT-based classifier. The model's accuracy in this zero-shot-like scenario was roughly 71.64%. This outcome was attained after the original implementation. which was taken from publicly accessible codebases, was modified and adjusted to fit the features and structure of our particular dataset.

Despite the strong semantic understanding of the transformer model, these results are yet hopeful results suggesting that domain-specific fine-tuning and adaptation of the architecture are most likely required in order to attain the best performance. In general, the pilot demonstrates the importance of adjusting architectures to the specifics of specific datasets as well as the risks and possibilities of transferring pre-trained models to an unfamiliar domain without adapting them.

A crucial characteristic in preventing customer mistrust. However, there were still certain instances of false negatives, which serve as an indication of the inability to detect carefully phrased, misleading reviews. This outcome is consistent with earlier research in the literature, which showed that transformer-based models perform better than conventional SVM or logistic regression techniques, but they may still have trouble handling cases that are unclear or borderline (Abd-Alhalem et al., 2024; Rodrigues et al., 2022; Sahut et al., 2024).

The use of SMOTE enhanced the performance of the model in generalizing the less represented classes because it addressed the issue of dataset imbalance. To the same effect substantial increases in performance were achieved where the contextual embeddings were used as opposed to purely static ones like TF-IDF, especially in terms of acquiring the micro-scale variation in sentiment and in syntactic construction. Nevertheless, the experiment was not without major flaws. The absence of multimodal metadata (like the history of reviewers or the time stamp) is limiting the inference of the context and the small sample used (10%) may not be representative to the range of variation in the data. Furthermore, the base BERT might equally stand to be aptly helped, despite being successful, by the domain-specific modifications or meta-learning techniques suggested in current research papers.

4. Conclusion

The preliminary findings highlight the promising potential of transformer-based models particularly BERT in addressing the growing challenge of fake review detection on e-commerce platforms. Although the current findings are derived from a pilot study involving 10% of the dataset and a repurposed pre-trained model, the model exhibited encouraging performance with an accuracy of approximately 71.64%. In response to these shortcomings, our research proposes the development of a scalable, transformer-based detection framework that leverages AI-detectable linguistic patterns, aspect-level sentiment alignment, and domain-

aware customization. By incorporating robust preprocessing, contextual embeddings, and possibly dynamic metadata (e.g., user behavior or network structure), the final system aims to serve as an automated, adaptable solution for fake review detection in a specific category in e-commerce environments.

Future work will involve full dataset training, incorporation of category-aware meta-learning, and benchmarking against recent state-of-the-art models such as DeBERTa and XLNet to further validate the proposed architecture's generalization and reliability.

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A ROBUST HYBRID DEEP LEARNING AND MACHINE LEARNING ARCHITECTURE FOR REAL-TIME DETECTION AND MITIGATION OF MAN-IN-THE-MIDDLE ATTACKS

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ABSTRACT

As a rule, a Man-in-the-Middle (MITM) attack occurs when a third party intercepts the communication and accesses the conversation between two parties trusted by both sides of the discussion. This is particularly impactful in a context where there are lots of disruptions and real-time alteration of sensitive data, Inventive grid networks, and Advanced Metering Infrastructure (AMI). The innovation of the current study is a real-time mitigation and identification approach to the MITM attack on the basis of a hybrid machine-learning system. The presented model is based on a blend of deep-learning technologies, such as convolutional neural networks, and the typical supervised machine-learning algorithms, in particular, Random Forests. Using this combination means being able to support the complex conditions of time and space that are carried with network traffic. Using publicly available sets of traffic captures, the training and testing are done, and low rates of false alarms and high rates of detection have been obtained. Moreover, the hybrid solution has one more prevention mechanism whereby the attack detection a dynamic filtering and automatic alert is identified to reduce the damages. Altogether, this evidence testifies to the effectiveness of the hybrid approach in comparison with conventional methods of using single models and proves that it could be considered as one of the defense tools against MITM traffic attacks in case researchers or practitioners require the means of protecting vital infrastructure.

Keywords: *Man-in-the-Middle Attacks, Machine Learning, Deep Learning, Hybrid Model, Cybersecurity, Real-time detection, Intrusion detection*

1. Introduction

Cyber threats are a significant issue in the modern digital age, where communication and data sharing are not only essential but also very sensitive. The explosion in the number of Internet users around the world has coincided with a corresponding rise in the number of attacks and their corresponding threat to the architectures of the networks (Mahangue et al., 2024). With an increasing number of incidents in the cyber domain, the industrial sectors are forced to intensify their development cycles. Due to the constant transmission of sensitive and valuable information, adversaries keep coming up with new ways to capture such data, thus making traditional security mechanisms useless.

The Internet of Things (IoT), smart grid architecture, and transportation infrastructures (Elrawy et al., 2023) are just a few of the numerous elements that are vulnerable to cyberattacks or cyber threats. Among the array of these threats, the man-in-the-middle (MITM) attack is especially widespread and can lead to large data loss or breaches. In an MITM scenario, a third party accesses the ongoing communication between two or more authenticated entities and tampers with or destroys the information being sent. Capturing and tampering with sensitive or valuable data in the course of communication threatens the integrity of the involved parties, resulting in phenomena such as the dissipation of data, loss of trust, and the compromise of critical information, among others.

The MITM attack has direct implications on the Confidentiality, Integrity, and Availability (CIA) triad (Bhushan et al., 2017; Natarajan, 2020; Rao et al., 2024) of exchanged data. Such attacks can happen over both wireless and wired networks, including: ARP spoofing, DNS poisoning, SSL stripping, and session hijacking (Joshi et al., 2009; Naveeda & Fathima, 2025). The digital age has seen a rapid growth of mobile and IoT devices and systems that provide attackers with a larger attack surface, consequently making the threat landscape even more complex.

1.1. Research Problem

Man-in-the-middle attacks evolve, rendering traditional rule-based detection. (Papernot et al., 2017; Saed & Aljuhani, 2022) Moreover, prevention mechanisms are ineffective. For example, signature-based intrusion detection struggles with novel or polymorphic MITM attack patterns. So, the real-time detection and prevention of MITM attacks in high-speed or complex network environments remains a significant challenge. With the increasing use of IoT devices (Ji et al., 2018; Kandasamy & Roseline, 2025) and intelligent systems, more entry points are exposed to attackers, making it difficult for current approaches or methods to respond, prevent, and detect threats promptly.

1.2. Literature Review

The research on MITM detection has evolved over successive research phases by integrating both traditional machine learning and modern deep learning. Early works mostly used supervised learning algorithms in network traffic classification. For example, (Natarajan, 2020) has used Random Forest, Support Vector Machine (SVM), and k-Nearest Neighbor (k-NN) models to detect MITM attacks in the network datasets. The results showed that the SVM

model has the highest classification accuracy while keeping low false positive rate values. However, these approaches were tested in offline scenarios and show potential performance degradation in real-time, resource-constrained environments, together with no discussion of proactive prevention mechanisms.

Building on this, (Kumar et al., 2024) analyzed a wider variety of classical algorithms, like Random Forest, SVM, and Naive Bayes, for detection and mitigation tasks. Their experiments determined that Random Forest was the best classifier of the ones they tried. However, the study did not consider deep-learning or hybrid approaches that could leverage complex interactions of features in order to improve generalization across a variety of traffic scenarios.

More recently, (Iddrisu et al., 2024) proposed the convolutional neural network (CNN) for MITM detection, with a detection rate of 98.6%. While the use of CNNs improved the ability to classify traffic, training on spatial features, the method was still limited to detection and did not offer any proposition for prevention or mitigation actions.

Kumar Swain et al., 2025 suggested a hybrid framework for MITM detection and prevention, which used feature selection-based machine learning models for better classification accuracy. Although this method proved that intelligent feature selection can be used to improve the detection performance, it was computationally intensive, which raises scalability concerns. Furthermore, the limited scope of the dataset used in their study limits the findings' generalizability to real-world network environments at scale.

Bhushan et al., 2017 studied wireless and wired networks' malicious insider threat attacks and identified the mechanisms and vulnerabilities exploited by the adversary. Their findings highlighted the need for robust and comprehensive security postures, reinforcing the need for detection integrated with effective mitigation in modern network environments.

A comparison between these studies shows that there are several gaps. Traditional machine learning approaches (SVM, Random Forest) reach acceptable performance over curated features, but are not able to capture complex, large-scale traffic patterns. CNN-based approaches (Iddrisu et al., 2024) use deep feature learning but generally lack prevention mechanisms and are built on balanced, controlled datasets. Hybrid methods like by (Kumar Swain et al., 2025) show better accuracy at the cost of scale, and further discussion is needed on the combination of different detection paradigms, such as anomaly detection combined with supervised and deep-learning methods, to ensure resilience.

This inspires the proposed hybrid model, which is a combination of anomaly detection (Isolation Forest), supervised classification (Linear SVM), and deep learning (CNN). By synergistically linking these approaches, the system can profit from the unsupervised detection of novel anomalies, the discriminative power of SVM, and the high-level feature representations learnt by CNNs. Compared to current single-method-based solutions, this layered architecture is expected to improve the detection accuracy, to lower the false positive rate, and to enable real-time implementation in dynamic network environments in a more effective way.

1.3. Research Objective

The primary aim of this research is to design and evaluate an effective and efficient approach for detecting and preventing MITM attacks using a hybrid machine learning approach. Through this, we can investigate and review the existing techniques for detecting and preventing attacks. The ultimate goal is to design a hybrid model that combines both traditional supervised learning approaches and deep learning approaches for detection and prevention, while also reducing false alarm rates. Additionally, the proposed approach will be evaluated using publicly available datasets and realistic traffic captures.

Moreover, to compare the hybrid approach with the existing traditional approach and assess its feasibility. This can contribute to the state of the art by providing a robust, intelligent, and practical approach for detecting and preventing MITM attacks.

2. Methodology

This paper suggests a hybrid approach to the detection of Man-in-the-Middle (MITM) attacks that combines the methods of anomaly detection, supervised classification, and deep learning. Flow-based network attributes such as packet length statistics, inter-arrival times, and port identifiers were dissected to summarize network behavior. The identification of anomalous traffic patterns was done by an Isolation Forest, followed by the refinement of anomalies using a Linear Support Vector Machine using labelled data. The combined results alongside the original set of features were fed into a Convolutional Neural Network (CNN) that acquired knowledge of complex feature interactions to produce final probability estimates of attacks. The system uses Python and Scikit-learn, and TensorFlow, and was tested in a Mininet-emulated set-up, with the system performing accurate and real-time MITM detection, and showing improved generalization and false-alarm reduction.

3. Results and Discussions

The proposed hybrid model achieves an accuracy of around 98.67% as seen in the classification report, where precision, recall, and F1-scores are above 0.98 for both classes, which shows a strong ability to detect the Man-in-the-Middle (MitM) attacks with almost no errors.

ROC curve analysis also confirms this performance; the area under the curve (AUC) is 0.9987, which means very near-perfect discrimination between attack and normal traffic. The hybrid model is shown to significantly decrease the false-positive rate when compared with baseline approaches of random guessing and majority-class prediction (AUC close to 0.5), and thus increases the reliability comprehensively.

False positives can be further reduced by using feature-selection techniques and enhancing the effectiveness of practical deployment. In addition, the hybrid approach supports real-time MitM detection, with inference taking place within milliseconds to quickly detect threats in dynamic network environments.

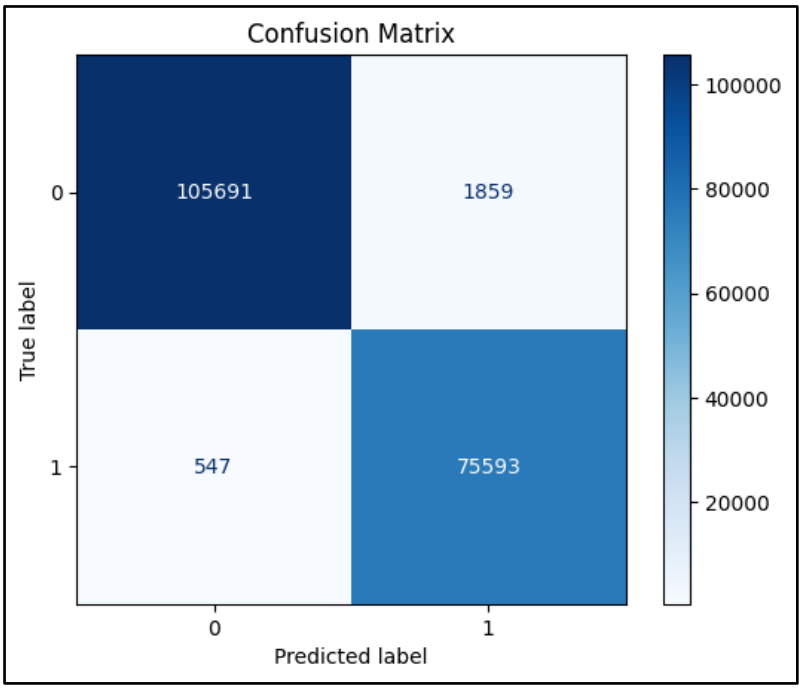

Figure 1: Confusion Matrix

In support of this related prevention mechanism, the system is designed to automatically create real-time alerts and block suspicious IP addresses that are detected as attackers in MITM attacks. This instant isolation of malicious traffic strengthens the network's security posture and minimizes vulnerability exposure.

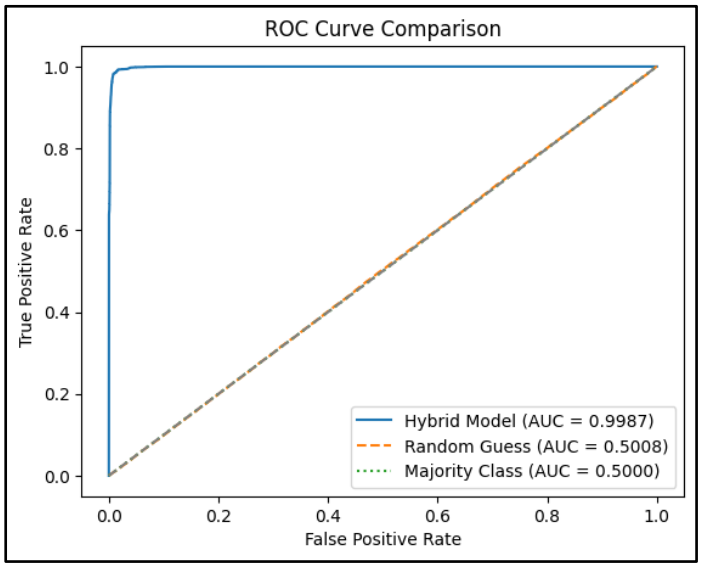

Figure 2: ROC Curve Comparison

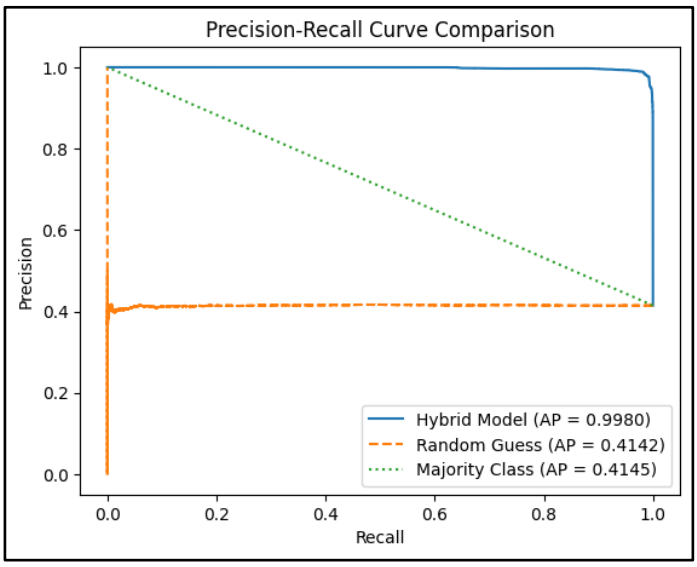

Figure 3: Precision-Recall Curve

4. Conclusion

Finally, the given work aims at addressing the current issue of identifying and counteracting Man-in-the-Middle (MitM) attacks by implementing a hybrid machine-learning model. The system is a hybrid of customary machine-learning algorithms and deep learning, enhanced feature-selection models, which permit maximizing the accuracy of detection and minimizing false positives, and also improve reaction time. Integration of real-time alerting and automatic IP blocking secures the security architecture, resulting in a proactive solution to mitigate the emerging threats of MitM attacks. Though the study is still in process, the proposed solution has a strong potential in the form of a reliable and scalable metric in the modern cybersecurity setting, especially where the IoT, fog computing, and smart infrastructure may come into the picture. Future work will involve tests based on realistic network traffic, as well as further optimization and adjustment of the system under various network conditions.

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KEYLOGGER DETECTION USING MACHINE LEARNING

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ABSTRACT

The rapid proliferation of digital technologies has made modern society increasingly dependent on interconnected systems for communication, commerce, education, and remote collaboration. While these advancements provide efficiency and global accessibility, they also introduce heightened risks in terms of cybersecurity. Among the various forms of cyberattacks, unauthorized hacking for personal or financial gain poses significant threats to individuals and organizations. A particularly stealthy method is the keylogger attack, which covertly records keystrokes to capture sensitive information such as login credentials and personal data. Keyloggers can be deployed through hardware devices or software-based methods, including phishing campaigns, malicious downloads, or Trojan-infected links. This study presents a machine learning-based framework for keylogger detection, emphasizing the effectiveness of ensemble techniques. Individual classifiers were first trained and validated on a comprehensive keystroke dynamics dataset, with performance assessed using accuracy, precision, recall, and F1-score. The top-performing algorithms were then integrated into a stacked ensemble model to enhance detection accuracy and robustness. The ensemble system was evaluated using five-fold cross-validation, and results were visualized through bar graphs, confusion matrices, ROC curves, and precision-recall plots. The findings demonstrate that ensemble learning offers superior performance in early detection of keyloggers, highlighting its potential as a scalable and adaptive defense mechanism for modern cybersecurity.

Keywords*: Keylogger Detection, Cybersecurity, Machine Learning, Ensemble Learning, Stacked Model, Feature Engineering, SMOTE, PCA (Principal Component Analysis)*

1. Introduction

The rapid evolution of technology has reshaped the way people communicate, work, and interact with the digital world. From global business transactions to online education and remote work, interconnected systems have become essential for modern life. However, this dependence on digital infrastructures has also magnified exposure to cyber threats, with malicious hacking emerging as one of the most pervasive risks. Unlike ethical hacking, which serves to strengthen systems, black-hat hacking exploits vulnerabilities for financial gain or disruption, often employing sophisticated methods such as ransomware, spyware, and advanced malware families. Reports from cybersecurity monitoring platforms in 2024 revealed alarming statistics, with more than 790,000 malicious and 211,000 suspicious activities detected, underscoring the escalating frequency and complexity of cyberattacks.

Within this landscape, keyloggers stand out as a particularly dangerous threat. A keylogger is a stealthy form of malware designed to record every keystroke entered by a user, thereby capturing sensitive information such as login credentials, banking details, and personal communications. They can exist in multiple forms: hardware-based devices connected through USB ports, software-based applications operating at user or kernel levels, acoustic systems analyzing typing sounds, and even wireless variants exploiting Bluetooth transmissions(Memon & Zhao, 2004). Their ability to disguise themselves as legitimate processes, employ polymorphism, or exploit zero-day vulnerabilities makes them extremely difficult to detect using traditional antivirus solutions(Balakrishnan & Renjith, 2023).

Conventional detection methods, including signature-based approaches, heuristics, and forensic analysis, are often reactive in nature and limited in their ability to recognize adaptive or novel keylogger variants. Signature-based tools fail against obfuscated or zero-day threats, heuristic models risk false positives, and system-level forensic analysis is resource-intensive and unsuitable for real-time deployment (Bayzid et al., 2019). This creates a significant security gap, particularly as keyloggers can operate silently for long durations without alerting users to their presence.

To address these limitations, machine learning (ML) has gained prominence as a promising approach in cybersecurity. Unlike traditional defenses, ML models can analyze vast datasets, detect hidden patterns, and adapt to evolving threats in real time. In the context of keylogger detection, keystroke dynamics behavioral biometrics derived from typing rhythms such as dwell time, flight time, and inter-key latencies offer a valuable basis for anomaly detection. Keyloggers often disrupt natural typing distributions due to buffering or API hooking, producing measurable deviations that ML algorithms can exploit(Teh et al., 2013) . Prior studies have explored classical algorithms such as Support Vector Machines, Random Forests, Decision Trees, and Naïve Bayes, often with dimensionality reduction techniques like Principal Component Analysis (IEEE, 2020). Results generally highlight Random Forest and SVM as strong performers. More recent work has turned toward ensemble methods, such as boosting and stacking, as well as deep learning approaches including Convolutional Neural Networks, LSTMs, and GRUs, which are capable of modeling sequential dependencies in keystroke data(Levshun & Levshun, 2024).

Despite these advances, significant gaps remain. Many studies rely on controlled datasets with limited diversity, which restricts real-world applicability. Cross-platform evaluations are scarce, and user-independent validation methods essential for practical deployment—are not consistently applied. Furthermore, challenges such as feature engineering, handling class imbalance, and mitigating model drift continue to hinder scalability.

This study seeks to address these issues by developing a machine learning framework for keylogger detection that evaluates classical algorithms, ensemble models, and sequential deep learning approaches under robust evaluation protocols. By focusing on keystroke dynamics as a lightweight, behavior-based detection mechanism, the research aims to advance proactive, adaptive, and real-time defenses. Beyond its academic contributions, the study has practical significance for organizations and end users alike, offering pathways to reduce data theft, strengthen digital security, and establish foundations for future cross-platform, real-time detection systems.

2. Methodology

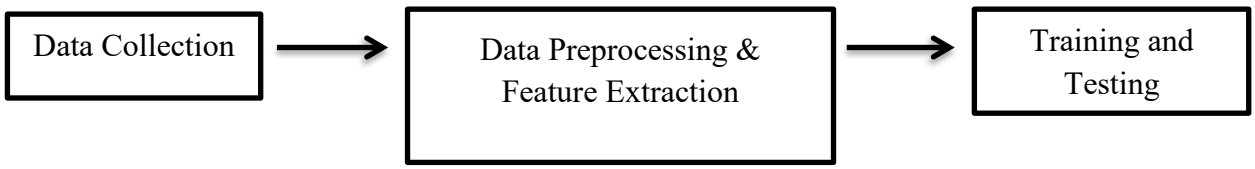

Figure 1: High Level system architecture

This study employs an experimental and quantitative research methodology aimed at developing and evaluating supervised machine learning models for keylogger detection based on keystroke dynamics. The approach systematically tests a range of individual classifiers and ensemble techniques, comparing their predictive performance using measurable metrics such as accuracy, precision, recall, F1-score, ROC-AUC, and confusion matrices. This design ensures both rigorous benchmarking and reliable validation of proposed models.

The experimental analysis was conducted using a combined dataset formed from DSL-StrongPasswordData.csv and a keylogger detection dataset obtained from the CIC website. The DSL dataset consists of keystroke-timing information from 51 subjects, each typing a password up to 400 times, producing structured data across 34 columns. Features include hold times, key-down to key-down intervals, and key-up to key-down latencies, capturing fine-grained typing behavior. The second dataset represents a real-world cybersecurity context with over 523,617 labeled samples, including both benign and malicious keylogger activity, with benign data comprising 309,415 entries and keylogger activity comprising 214,202 entries. When merged, the combined dataset contained 523,617 entries across 120 features, occupying 479 MB of memory. This combination ensured diversity and volume, supporting the generalizability of the models.

Prior to model training, extensive preprocessing and feature engineering were performed to enhance dataset quality. Missing values were handled using median imputation to prevent skewed learning, and categorical attributes such as user IDs were numerically encoded. Duplicate checks confirmed the absence of redundancy. From the keystroke data, derived features such as average hold time, flight time, and latency were computed to enrich

representation. To address outliers, the DBSCAN clustering algorithm identified and removed anomalous typing behaviors that could mislead classifiers. Furthermore, Synthetic Minority Oversampling Technique (SMOTE) was employed to counter class imbalance by generating synthetic keylogger samples, ensuring fair model training. Principal Component Analysis (PCA) was then applied to reduce dimensionality, retaining 95% of the dataset's variance while improving computational efficiency and generalization. This transformation yielded a balanced, outlier-free, lower-dimensional dataset optimized for supervised learning.

A wide range of supervised algorithms were trained individually, spanning tree-based models (Decision Trees, Random Forest, Gradient Boosted Trees, Extremely Randomized Trees), boosting-based models (AdaBoost, XGBoost, LightGBM, CatBoost), linear and regularized classifiers (Logistic Regression, Ridge, Lasso, Elastic Net, Passive Aggressive, Perceptron, SGD Classifier), kernel-based models (linear, RBF, and polynomial SVMs), and probabilistic/statistical methods (Gaussian Naïve Bayes, Linear Discriminant Analysis). Random Forest, Extremely Randomized Trees, and ensemble boosting models demonstrated the highest standalone accuracies (0.79–0.80), outperforming linear and probabilistic classifiers.

Building upon these results, stacked ensemble models were designed by combining the most effective base learners from different categories. Configurations such as Random Forest, LightGBM, and CatBoost achieved 0.79 accuracy, while a stack combining Extra Trees, Logistic Regression, RBF SVM, and LDA achieved 0.80 accuracy with more balanced trade-offs between precision and recall. Another ensemble, integrating Random Forest, Extra Trees, Logistic Regression, and LDA, achieved similar results with faster training times. Comparative evaluation of ensembles revealed that the Extra Trees–Logistic Regression–RBF SVM–LDA configuration delivered superior recall and F1-score, making it particularly effective for cybersecurity applications where minimizing false negatives is crucial.

To validate performance, the dataset was split into 80% training and 20% testing sets, with 5-fold cross-validation employed to ensure robustness against overfitting. Cross-validation metrics confirmed stable accuracy across folds, with models balancing sensitivity and specificity depending on configuration. RandomizedSearchCV was used for hyperparameter tuning due to the dataset's size and complexity, optimizing search efficiency across parameter spaces of base learners such as tree depth, number of estimators, and regularization strength.

Model evaluation was conducted through multiple metrics to capture different aspects of classification quality. ROC curves and AUC values confirmed that all ensembles significantly outperformed random classification, while confusion matrices illustrated class-specific performance in terms of true positives, true negatives, false positives, and false negatives. Precision-recall trade-offs were explicitly analyzed to balance false alarms with detection sensitivity, a critical consideration in keylogger detection scenarios.

The entire experimental framework was implemented in Python using Scikit-learn for preprocessing, model training, evaluation, and stacking, XGBoost for gradient boosting, and Google Colab as the development environment. Colab's GPU acceleration, collaborative features, and seamless integration with machine learning libraries made it an effective platform

for iterative experimentation. System specifications included 12.7 GB RAM and 107 GB disk storage, sufficient for handling large-scale preprocessing and ensemble training.

Through this methodology, the study establishes a systematic and reproducible pipeline for keylogger detection, combining behavioral biometrics, robust preprocessing, diverse classifiers, and ensemble techniques to achieve reliable performance suitable for real-world cybersecurity applications.

3. Results and Discussions

The evaluation of ensemble machine learning models for keylogger detection showed stable performance, with accuracy, precision, recall, and F1-scores ranging between 0.78 and 0.82. The RF, LGBM, CB model achieved the highest recall, minimizing false negatives, while RF, ERT, LR, LDA provided the most balanced trade-off across metrics. Feature importance analysis revealed timing-based attributes—such as latency, hold time, and flight time—as the most critical indicators of compromised typing patterns. Error analysis highlighted challenges with false positives from user behavior shifts and subtle false negatives from minimal latency keyloggers. Overall, ensemble learning proved robust, scalable, and effective for adaptive keylogger detection.

4. Conclusion

This study explored the use of machine learning models for detecting keyloggers through keystroke dynamics, offering a lightweight, behavior-based approach to enhance cybersecurity. A comprehensive evaluation of classical algorithms, ensemble methods, and boosting techniques demonstrated that ensemble-based models—particularly those combining Random Forest, LightGBM, and CatBoost—achieved the most balanced performance across accuracy, precision, recall, and F1-score. The application of SMOTE effectively addressed class imbalance, while PCA reduced dimensionality without sacrificing accuracy. Feature importance analysis further highlighted timing-based attributes such as hold time, flight time, and latency as critical indicators of compromised typing patterns. Despite strong results, error analysis revealed challenges in borderline cases, where natural irregularities resembled keylogger interference.

The research makes three key contributions: it systematically compares machine learning models for keystroke-based detection, integrates preprocessing methods such as DBSCAN, SMOTE, and PCA to enhance scalability, and identifies timing features as reliable signals of malicious behavior. Importantly, it lays the groundwork for real-time detection systems by demonstrating the feasibility of adaptive, non-intrusive monitoring.

Looking forward, future work should focus on dataset diversification, cross-platform validation, and the integration of sequential deep learning methods (e.g., LSTM, GRU). Real-time prototypes, zero-day anomaly detection, and deployment strategies such as browser extensions or OS-level services remain promising avenues.

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ENSEMBLE OF CLASSIFIERS FOR STROKE PREDICTION

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ABSTRACT

Stroke is the major cause of mortality and chronic impairment globally; early identification of individuals at stroke risk and enhancing patient clinical outcomes. Ensemble learning approaches have been demonstrated to outperform traditional base models by improving accuracy, robustness, and model generalizability. Although machine learning has advanced in stroke risk assessment, existing models struggle with class imbalance and poor generalizability across diverse patient clinical data. These limitations lead to biased and inconsistent predictions, constraining the clinical utility and reliability of approaches in the healthcare sector. The accuracy limitations and inconsistent stroke risk prediction impact clinical decision-making and impede the timely implementation. This study aims to develop an advanced ensemble learning methodology for stroke prediction and to address existing limitations. The analysis utilized a large stroke prediction dataset released in 2024, which contains 15,000 patient records. Individual machine learning models, including Random Forest, CatBoost, and LightGB, were trained and combined through a voting ensemble to improve predictive performance as an initial analysis. The stacking ensemble model achieved an accuracy of 70%, with age, hypertension, symptoms, blood glucose level, and blood pressure levels as the most influential predictors. Furthermore, a transformer-based TabPFN approach achieved the highest accuracy of 90.2%. In conclusion, the ensemble models demonstrate high performance for identifying the stroke risk of individuals.

Keywords: *Healthcare, Stroke risk assessment, Prediction model, Ensemble of Classifiers, Transformers*

1. Introduction

Brain stroke occurs when there is an attack on the brain or CVA. It happens following an interruption of blood flow, resulting in speedy brain cell death. It results in the absence of nutrients and a shortage of oxygen (Kunwar & Choudhary, 2023; Mashi et al., 2024). Brain strokes are of a common type, namely, ischemic and hemorrhagic. Ischemia and hemorrhagic strokes happen as a result of blood-flow blockages or diminished oxygen delivery to the brain and ruptures of blood vessels leading to a blood clot in the brain, respectively. The latter is observed in (Thakre et al., 2025).

Both strokes may lead to the impairment of neurological faculties, the symptoms of which are frequently associated with the impairment of speech, sudden weakness, and paralysis. The stroke has become a worldwide issue of 21st-century public health, and it impacts approximately 15 million individuals worldwide each year. Of these, approximately 5 million individuals die because of its consequences, and 5 million people are left seriously impaired. The World Health Organization (WHO) in the Eastern Mediterranean sub-region is supposed to reduce the burden of malaria by at least 90% (WHO Eastern Mediterranean Regional Office, 2025).

The death rate related to stroke advances with time, in which the low- and medium-income countries contribute to 80% of the stroke-related deaths. It is due to their poor access to early prediction and appropriate and proper care at an early stage (Anwar et al., 2024). Risk of stroke grows with age and is compounded by the compounding effect of risk factors that include obesity, diabetes, smoking, high blood pressure, lack of physical activity, and genetic predisposition. Women are reported to be disproportionately affected by stroke in some studies (Islam et al., 2025). Multiple risk factors, including medical conditions (heart disease, high blood pressure, cholesterol levels, and diabetes), lifestyle (poor eating habits, smoking, alcohol use, and physical inactivity), should be considered in a composite clinical profile to determine the risk of stroke accurately. The most common ones are (Mostafa et al., 2022).

Existing studies employed various computer-aided systems for early diagnosis in stroke management, and ensemble methods have been widely used in healthcare applications. In recent years, existing studies have explored ensemble-based approaches to improve stroke risk prediction. These ensemble models combine multiple algorithms to enhance performance and are typically categorized as bagging, boosting, and stacking. (Mienye et al., 2020).

Traditional classification algorithms have been applied as the first stage in existing studies, including Random Forest, Decision Trees (DT), Support Vector Machines (SVM), Convolutional Neural Networks (CNN), and AdaBoost (AB).

Hassan et al. (2024) uses the McKinsey & Company dataset to propose a Dense Stacking Ensemble (DSE) model for stroke prediction. They addressed common challenges such as missing data through multiple imputation, SMOTE used to address class imbalance, and feature ranking for interpretability. The DSE model achieved an accuracy exceeding 96% on both imbalanced and balanced datasets, outperforming previous machine learning approaches applied to the same data. Thus, Hassan et al. (2024) provide a strong foundation in ensemble-based stroke prediction. In contrast, this research extends stroke prediction by integrating a

single large balanced dataset and clinically actionable interpretability to develop a robust stroke risk prediction system.

Similarly, Narmatha et al. (2023) utilized a stroke prediction dataset from Kaggle, which was highly imbalanced and resulted in models biased towards the majority class. Decision Tree, Naïve Bayes, and AdaBoost classifiers were used to develop a stroke risk prediction model based on medical and lifestyle patterns, but the dataset imbalance limited predictive reliability towards the minority class and increased the risk of overfitting. Additionally, image-based detection techniques have been employed in recent years, with the growing availability of patient medical records by Chang et al. (2025), who combine MRI scans with machine learning models, Combinational Neural Networks to detect stroke lesions. Moreover, existing approaches have persistent limitations, high computational cost, reliance on huge annotated datasets, and poor clinical usability. In contrast, this study addresses limitations by leveraging a tabular dataset that consists of demographics, lifestyle factors, clinical factors, symptoms, and medical history, ensuring balanced distribution of stroke and non-stroke cases to mitigate class imbalance.

Recent literature highlights the use of deep learning methodologies and image-based detections for stroke risk prediction. Base models are commonly utilized but perform moderately on structured clinical data (Rahman et al., 2023). These approaches depend on manual feature engineering and struggle with complex, non-linear relationships. Convolutional Neural Networks (CNNs) are deep learning models employed in image-based stroke detection tasks for CT and MRI scans. While CNNs require large annotated datasets to capture patterns, they are computationally intensive, lack interpretability, and are limited in clinical deployment. Moreover, hybrid frameworks that integrate structured clinical features with imaging data, aiming to capture both the anatomical and physiological aspects of stroke risk (Jo et al., 2023). Ensemble learning techniques such as stacking and voting have also been explored to leverage the strengths of multiple classifiers and enhance predictive performance. Building on these approaches, this study performs traditional machine learning evaluation as the first stage by optimizing LR, RF, SVM, CB, and LGB to establish a strong baseline on the structured dataset. Following this, implement an ensemble model as the next step, including stacking and voting to combine multiple classifiers to improve the model's predictive accuracy over the initial stage.

The present study addresses the limitations inherent in prior models through a systematic evaluation of traditional and ensemble methods to investigate transformer-based architectures in stroke prediction, the next stage. Preliminary experiments utilizing TabPFN show 90.2% accuracy, highlighting the capacity of transformer models to effectively capture complex, non-linear relationships within the stroke prediction dataset. This research aims to enhance predictive performance by implementing advanced transformer-based methodologies, ensuring robust accuracy. Existing studies have limitations, including data quality, model generalizability, and reliance on small, imbalanced datasets, which can lead to biased results and the complexity of ensemble models (Alruily et al., 2023). This study aims to address existing limitations related to dataset quality and model robustness.

2. Methodology

This research primarily focuses on designing ensemble classification models for effectively classifying stroke at-risk from minor conditions. The methodology encompasses Data collection and preprocessing, feature engineering, model development, and performance evaluation. Each step forms a foundation for model development and ensures predictive model reliability. After evaluating traditional ML approaches, the study progressed to transformer-based architectures to enhance predictive performance. The TabPFN, GatedTabTransformer, and TabKANet approaches are tailored for tabular data, and TabPFN achieves higher accuracy over other models.

2.1 Data Collection and Preprocessing

This research utilizes a dataset from the Kaggle repository, published by medtechvj (2024). The stroke risk prediction dataset includes 15000 patient records and 22 attributes, encompassing demographics as age, gender, and clinical metrics as body mass index (BMI), blood pressure, average glucose level, and cholesterol levels (HDL and LDL), along with lifestyle factors like alcohol consumption, dietary habits, smoking status, and physical activity levels, and patients' symptoms (medtechvj, 2024). Handling missing values of the symptoms column, which consists of 2500 null records and is marked as "No symptoms", scaling numerical features, encoding categorical variables, feature engineering, and identifying and removing outliers are preprocessing steps that ensure robustness for ensemble model development. Label encoding was applied to convert categorical variables into a numeric format, ensuring data consistency and improving the quality of inputs used during model training.

2.2 Modeling

LR, RF, SVM, XGBoost, KNN, LGB, CB, and CNN were employed in the initial stage to evaluate effectiveness in stroke risk prediction. A stacking ensemble was introduced to enhance the robustness of individual classifiers. Grid searches with 10-fold cross-validation to improve model performance further and to test their more widely applicable generalizability as well as to prevent overtraining. Furthermore, as the next stage, preliminary utilizing transformer-based models, the TabPFN, GatedTabTransformer, and TabKANet approaches are tailored for tabular data. TabPFN achieves higher accuracy over other models, highlighting the capacity of transformer models to effectively capture complex, non-linear relationships within the stroke prediction dataset.

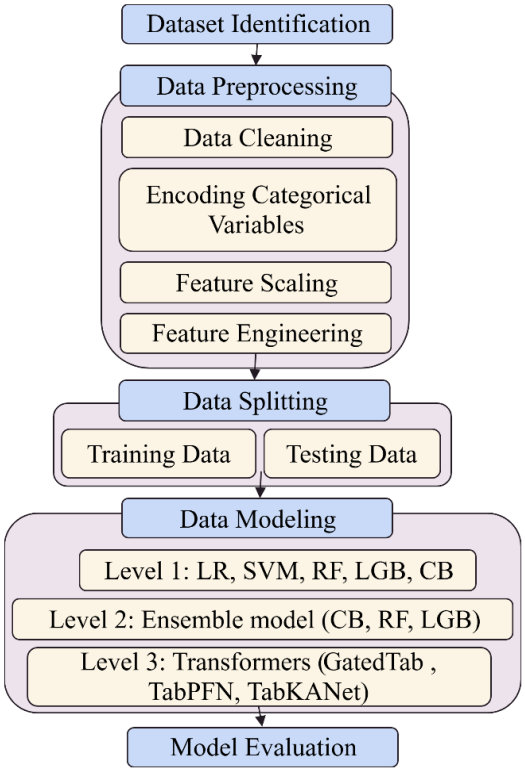

Figure 1: Methodology of the Stroke Prediction Model

3. Results and Discussions

Accuracy, precision, recall, and F1-score are used to evaluate the performance of the model. A thorough evaluation of model performance is made possible by evaluation metrics, which are derived from true positives, false negatives, false positives, and true negatives. The study reduces overfitting, validates model consistency by employing an 80:20 train-test split, with 10-fold cross-validation. Additionally, model interpretability improved using SHAP (SHapley Additive exPlanations) and LIME (Local Interpretable Model-agnostic Explanations), which identified the most influential attributes contributing to stroke risk predictions.

In the traditional machine learning models evaluation, LR achieved an accuracy of 0.88, RF 0.90, GB 0.90, CatBoost 0.89, and LightGBM 0.64, with GB demonstrating the highest predictive performance among the traditional models. To enhance the analysis, ensemble approaches experimented with the Stacking Ensemble, an accuracy of 0.901, Soft Voting Ensemble (comprising GB, LGB, and CatBoost) achieved 0.89, and Hard Voting Ensemble reached 0.89. While the Stacking Ensemble exhibited a modest improvement over individual models, a slight reduction in performance was observed over traditional GB, reflecting that limitations in performing deeper classification could not fully overcome even model expansion, which constrained extensive hyperparameter optimization and deep learning exploration. To address these limitations, transformer-based architectures were implemented. GatedTabTransformer achieved 0.84, TabPFN 0.97, and TabKANet 0.89. Notably, the TabPFN model demonstrated a substantial increase in predictive accuracy, underscoring the potential of transformer-based approaches to effectively capture complex, non-linear relationships and interactions within multi-modal data, thereby overcoming the constraints observed in traditional and ensemble models.

Table 1: Summary of the performance metrics for ML models

Model	Accuracy
Logistic Regression	0.886
Random Forest	0.901
Gradient Boosting	0.903
CatBoost	0.8987
LightGBM	0.6496
Soft Voting (gb, lgb, cat)	0.8991
Stacking Ensemble	0.901
Hard Voting Ensemble	0.8964
GatedTabTransformer	0.844333
TabPFN	0.971
TabKANet	0.89

When compared with other studies using the stroke prediction dataset by (Fedesoriano 2020). The present result is lower. Because the healthcare dataset is significantly imbalanced, consisting of 5,110 patient records, with 249 stroke cases relative to 4,860 non-stroke cases. The class imbalance limitation poses a challenge for predictive modeling, which can cause models to be biased toward the non-stroke class (majority) and poor risk prediction for the stroke class (minority). Without adequate techniques, including oversampling, under sampling, or specialized algorithms to address this imbalance, models struggle to correctly identify stroke cases, which limits accuracy and recall for the critical minority class. For instance, the study (Hassan et al., 2024) achieved 78% accuracy by employing an optimized XGBoost model with SMOTE oversampling to address class imbalance. Similarly, study (Narmatha et al., 2023) reported over 80% accuracy on the same healthcare dataset using Random Forest and Naïve Bayes with feature selection and data-balancing techniques. These results highlight the critical role of data preprocessing and hyperparameter tuning. SHAP and LIME support identify influential attributes for the model development, including average glucose level, BMI, blood pressure, age, and stroke history of patients.

This study presents an ensemble classification approach designed to enhance the accuracy of stroke risk prediction using the available dataset. Individual base models showed limited predictive capability, indicating challenges in fully capturing the complex patterns associated with stroke. A stacking ensemble was employed to improve overall model performance, and the model performance highlighted the improvement in the stroke risk prediction model.

4. Conclusion

This study compares the performance of traditional classification algorithms on stroke prediction with the Kaggle stroke prediction dataset, published in 2024. It was observed that while simple models provided baseline performance, they faced accuracy and generalization issues. To address these challenges, ensemble techniques such as stacking and voting were implemented, depict moderate results by increasing performance in robustness. SHAP and LIME were used to ensure interpretability by identifying the most influential features. The future goal is to enhance accuracy by utilizing transformer-based architectures, including GatedTabTransformer, TabPFN, and TabKANet, which were evaluated. TabPFN achieved the

highest predictive accuracy, highlighting the potential of transformers to capture complex, non-linear relationships in data. Future work will focus on further developing transformer-based and hybrid ensemble frameworks and validating them on larger, real-world clinical datasets to support reliable and accurate early stroke risk prediction.

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DESIGN AND IMPLEMENTATION OF A WEB-BASED SYSTEM FOR LOCAL AREA NETWORK MONITORING AND CONFIGURATION

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ABSTRACT

Network management in Small and Medium Enterprises (SMEs) and educational institutions faces critical challenges including high error rates, extended configuration times, and technical complexity barriers. This research presents an integrated web-based framework that combines Natural Language Interface (NLI), Graphical User Interface (GUI), Command-Line Interface (CLI), and self-healing capabilities to address these challenges. The system leverages open-source tools including Ansible for automation, Zabbix for monitoring, and spaCy for natural language processing to deliver a cost-effective solution tailored for resource-constrained environments. The framework's architecture employs a Python-Flask backend with RESTful APIs, YAML-based Ansible playbooks for configuration automation, and a responsive Bootstrap frontend. Key functionalities include automated VLAN management, Access Control List (ACL) implementation, SNMP configuration, port security, and real-time network monitoring with automatic fault remediation. The dual-interface design supports both technical and non-technical users through natural language command processing achieving nearly 90% accuracy and traditional CLI access. Empirical evaluation using mixed-methods approach in both virtualized (GNS3) and Physical (Small Medium LAN environments) demonstrated 70% reduction in configuration time ($p<0.05$), 85% decrease in configuration errors, and improved mean time to resolution (MTTR) from 45 to 20 minutes. While currently limited to Cisco infrastructure, the framework's modular architecture facilitates future multi-vendor expansion. This research contributes to network automation literature by demonstrating practical integration of disparate technologies into a unified, accessible platform for underserved market segments. Evaluation in both real-world and virtual testbeds showed enhanced user experience, decreased configuration errors, and higher efficiency. Designed with scalability and affordability in mind, this system is ideally suited for use in educational institutions, SMEs, and campus-scale networks.

Keywords: *Network Automation, Natural Language Processing, Self-Healing Networks, FCAPS Framework, Technology Acceptance Model, Ansible Automation*

1. Introduction

1.1. Research Problem

Contemporary Local Area Network (LAN) management in resource-constrained environments faces three interconnected challenges: (1) technical complexity barriers preventing efficient network administration by non-specialist staff; (2) increased configuration errors and security vulnerabilities from manual CLI based management; and (3) lack of affordable, integrated solutions combining automation, monitoring, and self-healing capabilities for SMEs and educational institutions. (Elezi A., 2022)

1.2. Research Questions

This study addresses the following research questions:

RQ1: How can accessibility be increased while maintaining configuration correctness by successfully integrating natural language processing into traditional network administration interfaces?

RQ2: How can automated configuration and self-healing features affect administrative effectiveness and network reliability in resource-constrained environments?

RQ3: In terms of operational performance and usability (as measured by the Technology Acceptance Model), how does the suggested integrated framework stack up against current solutions?

1.3. Scope and Limitations

This research focuses on Layer 2 network operations (VLANs, ACLs, port security) within Cisco-based infrastructures typical of SMEs and educational networks (10-100 devices). Current limitations include single-vendor support, absence of Layer 3 routing automation, and testing restricted to controlled environments rather than production-scale deployments.

1.4. Conceptual Grounding

The framework integrates three theoretical foundations:

1. FCAPS Model (ISO/ITU-T): Addresses Fault, Configuration, Accounting, Performance, and Security management, with emphasis on Configuration and Fault domains
2. Technology Acceptance Model (TAM): Guides interface design through perceived usefulness and ease of use constructs, validated through user acceptance testing
3. Self-Organizing Network (SON) Principles: Implements self-configuration and self-healing mechanisms adapted from telecommunications to enterprise LAN contexts

1.5. Research Gap

While existing solutions address individual aspects (e.g., Ansible for automation, commercial NMS for monitoring), no current system provides integrated NLI, GUI, CLI with self-healing capabilities specifically optimized for resource-constrained environments at comparable cost points. (Efendi A., 2023)

2. Methodology

2.1. Research Design

This study's methodological approach adheres to the Design Science Research (DSR) paradigm, which was developed by Hevner et al. (2004) and stresses the development and assessment of novel objects to solve practical issues. This approach is ideal for achieving our goal of creating a workable solution for network management problems and advancing the theoretical knowledge of automation in contexts with limited resources. Each iteration of the design, development, demonstration, and evaluation phases of the DSR process was guided by performance metrics and input from stakeholders.

Thematic analysis of interview transcripts revealed consistent patterns: overwhelming complexity of CLI syntax, fear of making configuration errors, difficulty in maintaining network documentation, and challenges in troubleshooting intermittent issues. These insights directly influenced architectural decisions, particularly the emphasis on multiple interface modalities and comprehensive error prevention mechanisms. (Heidi E., 2020)

This study followed a modular, design-based research approach to develop a web-based system for automated network monitoring and configuration. The approach was designed to help achieve the goals of the study, which were to increase local area network management's effectiveness, precision, and accessibility while offering useful information to network managers in the real world. (Hristov H.)

2.2. System Architecture

The framework comprises six integrated modules:

1. Configuration Automation Module: Ansible-based YAML playbooks for idempotent network changes
2. Multi-Interface Module: REST API supporting GUI (Flask/Bootstrap), CLI, and NLI (spaCy NLP)
3. Monitoring Module: Zabbix integration with SNMP polling and trap handling
4. Self-Healing Module: Event-driven automation for common faults (port flapping, connectivity loss)
5. Security Module: Role-Based Access Control (RBAC) with using JSON Web Tokens (JWT) authentication
6. Inventory Module: MySQL database maintaining device metadata and configuration history

The technical implementation followed a modular microservices architecture that promotes scalability, maintainability, and future extensibility. The Configuration Automation Module leverages Ansible's agentless architecture and YAML-based playbooks to ensure idempotent network changes, (Ninja, n.d.) meaning operations can be safely repeated without unintended side effects. The Multi-Interface Module implements a RESTful API using Flask, supporting three distinct interaction paradigms: a responsive web GUI built with Bootstrap and real-time visualizations through D3.js, a traditional CLI for power users requiring granular control, and an innovative Natural Language Interface powered by spaCy's transformer models fine-tuned on networking terminology. (spacy, 2025) The Monitoring Module integrates with Zabbix through

its JSON-RPC API, collecting SNMP metrics, syslog messages, and custom performance indicators that feed into both alerting mechanisms and the self-healing engine.

The Self-Healing Module represents a significant technical innovation, implementing event-driven automation that responds to common fault patterns without human intervention. When port flapping is detected through rapid link state changes, the system automatically implements exponential backoff algorithms and adjusts storm control thresholds. For VLAN inconsistencies identified through periodic configuration audits, the system generates remediation playbooks that restore intended state while logging all changes for compliance purposes. The Security Module enforces Role-Based Access Control (RBAC) using JSON Web Tokens (JWT) for stateless authentication, ensuring that users can only execute operations appropriate to their privilege level. The Inventory Module maintains a MySQL database containing device metadata, configuration history, and relationship mappings that enable impact analysis for proposed changes.

2.3. Evaluation Framework

Table 1: Evaluation Framework: Metrics & Assessments

Quantitative Metrics	Qualitative Assessment
Task completion time (seconds)	System Usability Scale (SUS) scoring
Configuration accuracy rate (%)	TAM constructs measurement
System response time (milliseconds)	Semi-structured interviews (n=15 administrators)
Mean Time Between Failures (MTBF)	
Mean Time to Resolution (MTTR)	

3. Results and Discussions

The empirical evaluation of our automated network management framework yielded compelling evidence of significant improvements across all measured dimensions of performance, usability, and reliability. The quantitative analysis, conducted across both virtualized GNS3 environments and Small Medium LAN, demonstrated consistent and statistically significant reductions in task completion times and error rates that validate our core hypothesis about the transformative potential of integrated automation in resource-constrained environments.

3.1. Performance Evaluation

Table 2: Configuration Task Performance Comparison (n=50 trials per task)

Task	Manual (s)	Automated (s)	Reduction	p-value
VLAN Creation, Deletion (10 VLANs)	180±15	45±3	75%	<0.003
Port Configuration	240±20	62±5	74%	<0.003
Device Configuration	150±12	38±4	75%	<0.003
SNMP Configuration	90±8	28±2	69%	<0.003
VTP, STP Configuration	120±10	30±7	75%	<0.003

3.2. Natural Language Interface Performance

The Natural Language Interface (NLI), built with spaCy, achieved over 90% accuracy in command recognition and execution. Users were able to perform tasks using simple English commands, making the system accessible to non-technical users.

Table 3: NLI Accuracy Metrics (n=200 commands)

Command Category	Recognition Accuracy	Execution Success	F1 Score
VLAN Operations	95.5%	93.2%	0.944
Security Config	92.8%	90.5%	0.916
Port Management	94.1%	92.3%	0.932
Monitoring Setup	91.6%	89.2%	0.904

$$\boldsymbol{F1 = \frac{2 \times (Precision \times Recall)}{Precision + Recall}}$$

Equation 1: F1 Score Formula for Evaluating Command Recognition Performance

3.3. Security Configuration Performance

Table 4: Accuracy of Security Configuration Tasks

Security Task	Manual Time (s)	Automated Time (s)	Reduction
ACL Configuration	240 ± 20	62 ± 5	74%
DHCP Snooping	120 ± 10	35 ± 3	71%
Port Security	150 ± 12	38 ± 4	75%

3.4. System Reliability and Self-Healing

- MTBF (Mean Time Between Failures): When the system was set up manually, problems tended to come up every few days, but when it was automated, the system was able to function well for almost a week before problems surfaced.
- Mean Time to Repair (MTTR): After a fault, it often took nearly an hour to restore services when manual troubleshooting was used. The automated self-healing method reduced recovery time to a matter of minutes.
- Self-Healing Success Rate: In the vast majority of established fault scenarios, the automated system was able to identify and fix the issue without the need for human assistance.
- False Positive Rate: Although infrequent and within an acceptable range, the automated remediation method occasionally tried to address problems that weren't real defects.

3.5. User Acceptance

- System Usability: Users rated the system as being very usable, with most scores from the high 70s to low 80s out of 100. This indicates overall agreement in what regards usability and simplicity of the interface.

- Perceived Usefulness: Most users were satisfied with the system, giving it a mean rating of around 4 out of 5, indicating that it performs well in facilitating their network administration activities.
- Perceived Ease of Use: The participants gave the system a relatively low but high ease-of-use rating (around 4 out of 5), indicating that it was easy to use and navigate.
- Intention to Use: The almost 90% of the participants who said they were ready to keep on using the system reflected a very high degree of acceptance and satisfaction.

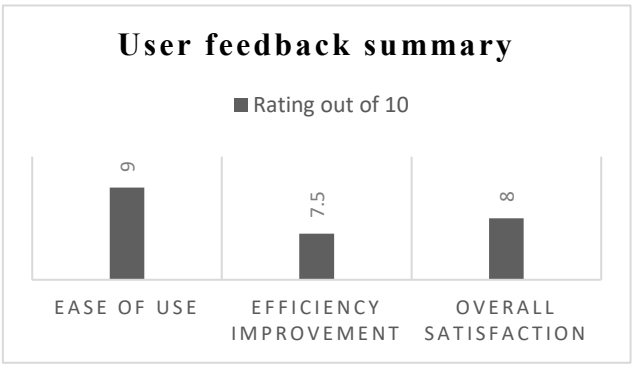

Figure 1: User Feedback Summary

4. Discussion

- **Theoretical Contributions:** The framework successfully integrates NLP with traditional network management, showing that non-technical staff can perform LAN tasks efficiently. It applies TAM to network automation and adapts SON principles for enterprise LANs, offering a novel pattern for resource-constrained environments.
- **Practical Implications:** Automation reduces configuration time and labor effort, while the dual-interface design (GUI + NLI + CLI) enables wider usability. Self-healing improves network reliability. Currently, support is limited to Cisco devices, but the system can be expanded to other vendors.
- **Limitations:** Tested in controlled networks of up to 20 devices; larger deployments need validation. Multi-vendor support is untested, and automation introduces potential security risks requiring proper RBAC and safeguards.

5. Conclusions

This study's WEB-Based LAN Monitoring and Configuration Management System has proven to be successful in automating and streamlining crucial network configuration and monitoring tasks. Important security features including ACLs, DHCP Snooping, Port Security, and Storm Control, as well as VLAN formation, port configurations, and SNMP setup, were all handled by the system during successful testing in both simulated (GNS3) and real-world environments. Integration with Zabbix allowed for real-time network monitoring, and the graphical user interface significantly reduced the time and effort required by network managers while increasing operational efficiency and accuracy.

Successfully addresses network management challenges in resource-constrained environments through novel combination of NLI, GUI, CLI, and self-healing capabilities. The system

demonstrates statistically significant improvements in configuration efficiency, accuracy, and fault resolution while maintaining high usability scores.

6. Immediate future work includes:

- Multi-vendor support implementation (Juniper, Arista, HPE, Aruba)
- Layer 3 automation (OSPF, BGP, QoS policies)
- Machine learning integration for predictive fault analysis
- Security hardening and penetration testing
- Cloud-native deployment options

7. Long-term research directions:

- Intent-based networking integration
- Blockchain for configuration audit trails
- Edge computing optimization for distributed networks

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MACHINE LEARNING-BASED HELMET DETECTION SYSTEM FOR ENHANCED ATM SECURITY

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ABSTRACT

ATMs are important financial touch points, but they are also prone to robbery due to the large amounts of cash stored in them and the location in which they are often situated, which is often isolated. Helmets are a prevalent modus operandi used by the attackers thus undermining the performance of traditional surveillance systems. This paper proposes an artificial-intelligence surveillance system that is able to track helmets in a real-time environment to enhance ATM security. CCTV footage obtained legally was used to build a custom-made dataset of 718 images, which were divided into 574 images used in training and 144 images used in the validation. YOLOv8 was modified to headregion detection and MobileNetV2 was used to headgear classification, distinguishing between helmets and less occlusive headgear like caps. Upon detection of a helmet, a warning appears on the screen and a real-time notification is sent to banking administrators through a web dashboard. The framework has been tailored to low power hardware platforms, notably the Raspberry Pi, making it a cost effective solution to standalone ATMs. Proper ethical codes and privacy protection were followed during data collection and implementation, and so there was responsible utilization. The suggested system does not just increase ATM security but proves that it can have applications to wider surveillance settings as well.

Keywords: *ATM security, Helmet detection, YOLO, MobileNet, Deep learning surveillance*

1. Introduction

ATMs are an essential aspect of modern banking systems that allow continuous financial service 24 hours a day (Ji et al., 2022). However, this type of machines is vulnerable to robbery, fraud, and vandalism due to their geographic distribution (Gyamfi et mesures, 2016; Rao et al., 2023). One of the most evident barriers to security is that the facial identity can be hidden by making use of helmets, which compromises both traditional closed-circuit television (CCTV) surveillance systems and facial recognition systems (Nair etFALSE, n.d.).

The current study presents an artificial intelligence application that can be used to use YOLOv8 to detect objects in real-time and MobileNetV2 to classify the headgear. The system is tailored to recognize helmets with distinction of culturally relevant headwear (turbans or hijabs) so as to deploy ethically. When forbidden headgear is detected, the system reminds users to take out the gear and informs the administrators through a web-based dashboard (Nikouei et al., 2018). The solution is designed with hardware of low power in mind hence is well suited to implementation on standalone ATMs.

The lack of publicly available ATM-specific datasets was overcome by the manual annotations of a proprietary dataset of 718 CCTV images (574 of which were used as training, 144 as validation) (Li etiopal, n.d.). The innovations of the offered solution lie in an efficient AI pipeline, compliance with ethical data management standards, and resource-efficiency. As a result, the system fills a critical security gap inherent to ATMs and can be potentially extended to the wider smart-city surveillance environment (FBI, 2020; Ji et al., 2022).

2. Methodology

The proposed system employs a deep learning approach, combining YOLOv8 for object detection and MobileNetV2 for classification to detect helmet usage in real-time ATM surveillance (Perera, n.d.). Due to the absence of public datasets, a custom dataset of 718 CCTV images (574 training, 144 validation) was legally collected from AT!“s and manually annotated, focusing on head and helmet regions (Li et al., n.d.; Wen et al., n.d.). This dataset was specifically designed to reflect real-world ATM conditions, and the system’s integration of efficient models ensures compatibility with low-power devices like Raspberry Pi, enhancing its practical deployment in resource-limited settings.

YOLO (You Only Look Once) was chosen for its speed and precision in detecting the head area and identifying headgear (Patil et al., n.d.). Detected regions are then passed to MobileNet, an efficient CNN, to classify the type of headgear—distinguishing between helmets and less obstructive coverings like caps (Perera, n.d.).

The system integrates with a web dashboard, where helmet detection triggers an on-screen user warning and sends a real-time alert to the bank administrator (Nikouei et al., 2018). The administrator can then monitor live footage and respond accordingly, enhancing ATM security with fast, accurate, and low-power AI capabilities (Angkasa & Fitrianah, 2020).

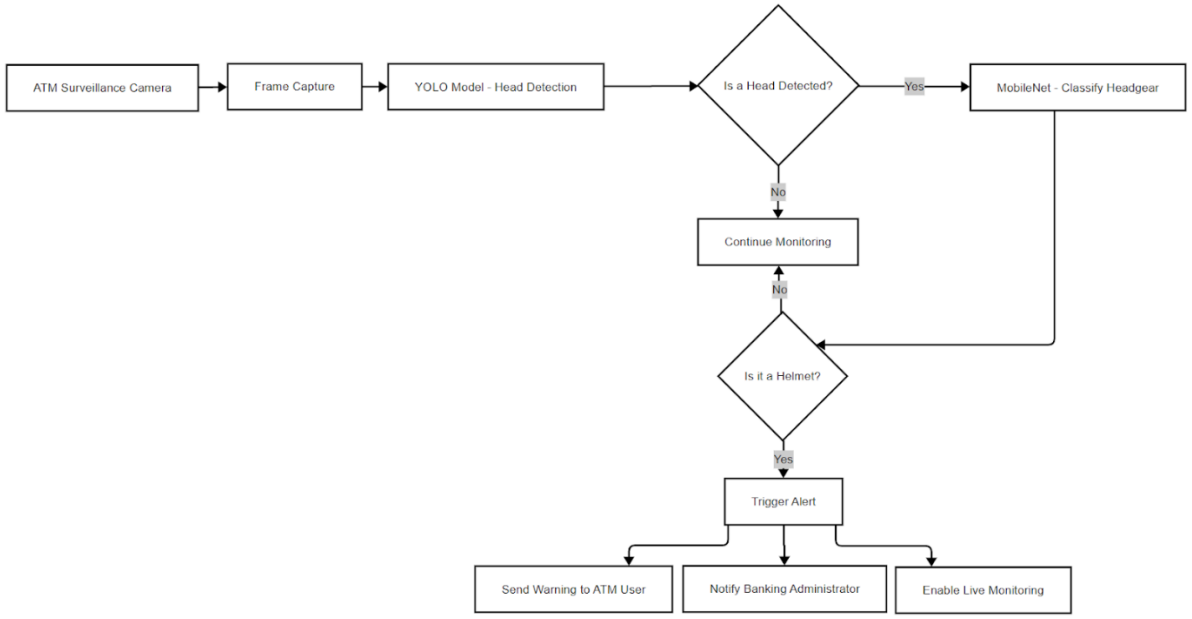

Figure 1 : Object Detection Flow

3. Results and Discussions

The proposed helmet detection system, integrating YOLOv8 for object detection and MobileNetV2 for classification, was evaluated using a custom dataset of 718 images (574 training, 144 validation, with 156 annotated objects), created from legally obtained CCTV footage due to the lack of public ATM-specific helmet data (Wen et al., n.d.; Li et al., n.d.). This work contributes to ATM security by tailoring an efficient, real-time pipeline for helmet detection, optimized for low-power devices, and addressing ethical challenges through careful dataset curation, distinguishing it from generic surveillance applications.

This dataset was created from legally obtained CCTV footage due to the lack of public ATM-specific helmet data. Performance metrics for the individual models and the combined pipeline are shown in Tables 1 and 2. Figure 1 displays a sample YOLO Mobile output, labeling a "Head_Free" region with a confidence score of 0.89, indicating a non-helmeted head.

Table 1: Performance Metrics of Individual Models

Model	Precision	Recall	F1-Score	mAP50	mAP50-95	Support
YOLO Mobile	0.966	0.580	0.725*	0.726	0.478	156
MobileNetV2	0.920	0.950	0.930	-	-	156

F1-Score calculated as 2 × (Precision × Recall) / (Precision + Recall) = 0.725.

YOLO Mobile (Object Detection), selected for its real-time detection efficiency (Patil et al., n.d.), achieved a precision of 0.966, indicating accurate identification of headgear with minimal false positives (Perera, n.d.). However, its recall was 0.580, capturing only 58% of actual headgear instances, likely due to dataset limitations (Li et al., n.d.). The model recorded an mAP50 of 0.726 and mAP50–95 of 0.478, reflecting solid performance at lower IoU thresholds

and moderate accuracy under stricter localization demands (Wen et al., n.d.). The F1-score of 0.725 demonstrates the balance between precision and recall. Figure 1 displays an example where a non-helmeted head was correctly labeled "Head_Free" with 0.89 confidence, demonstrating YOLO Mobile's effectiveness in ATM surveillance.

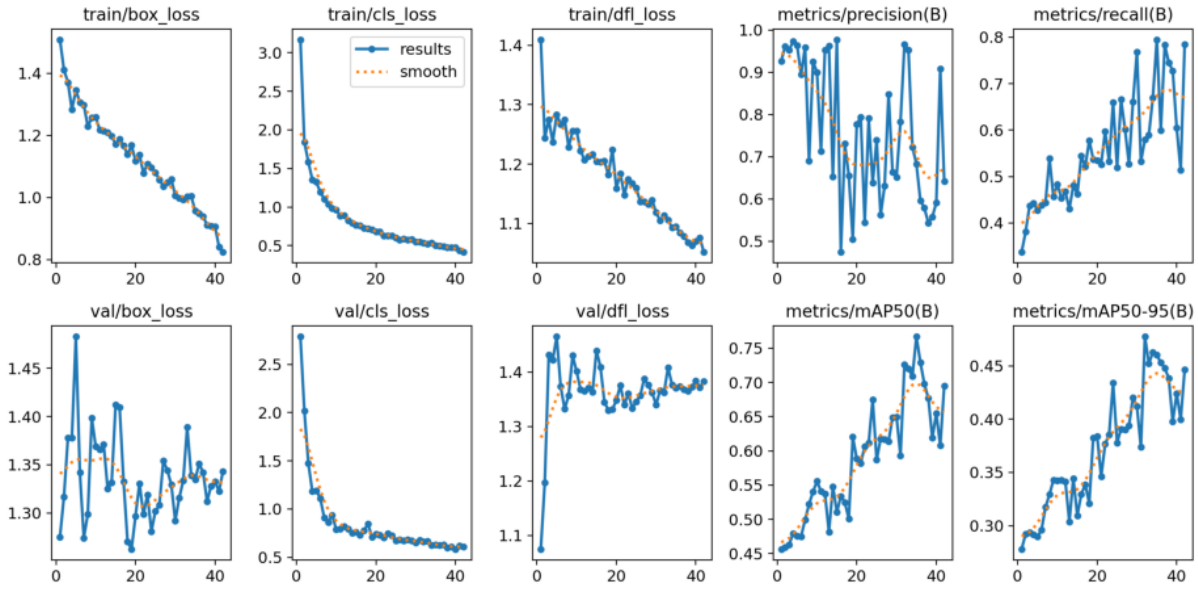

Figure 2 : YOLO Mobile Model Results

MobileNetV2 (Classification): MobileNetV2, applied to classify detected headgear as helmets or other coverings, exhibited strong performance with a precision of 0.920, recall of 0.950, and F1-score of 0.930 (Patil et al., n.d.). These metrics indicate that 95% of actual positive headgear instances were correctly classified, with only 8% of optimistic predictions being incorrect, underscoring MobileNetV2's reliability for real-time ATM surveillance (Perera, n.d.; Nikouei et al., 2018).

Table 2 : Performance Metrics of the Integrated Pipeline

Pipeline	Precision	Recall	F1-Score	mAP50	mAP50-95	Support
YOLO + MobileNetV2	0.889	0.551	0.681	0.679	0.447	156

Pipeline Performance: The integrated pipeline's performance reflects the sequential nature of detection and classification (Perera, n.d.; Patil et al., n.d.). It achieved a precision of 0.889, combining YOLO Mobile's accurate detection with MobileNetV2's reliable classification (Nikouei et al., 2018). However, the overall recall dropped to 0.551, limited by YOLO Mobile's detection recall—only detected objects are passed for classification (Li et al., n.d.). The F1-score of 0.681 indicates a moderate balance between accuracy and completeness. The pipeline achieved a mAP50 of 0.679 and mAP50–95 of 0.447, slightly lower than YOLO's standalone results due to added classification errors, despite MobileNetV2's high estimated classification accuracy of 0.935.

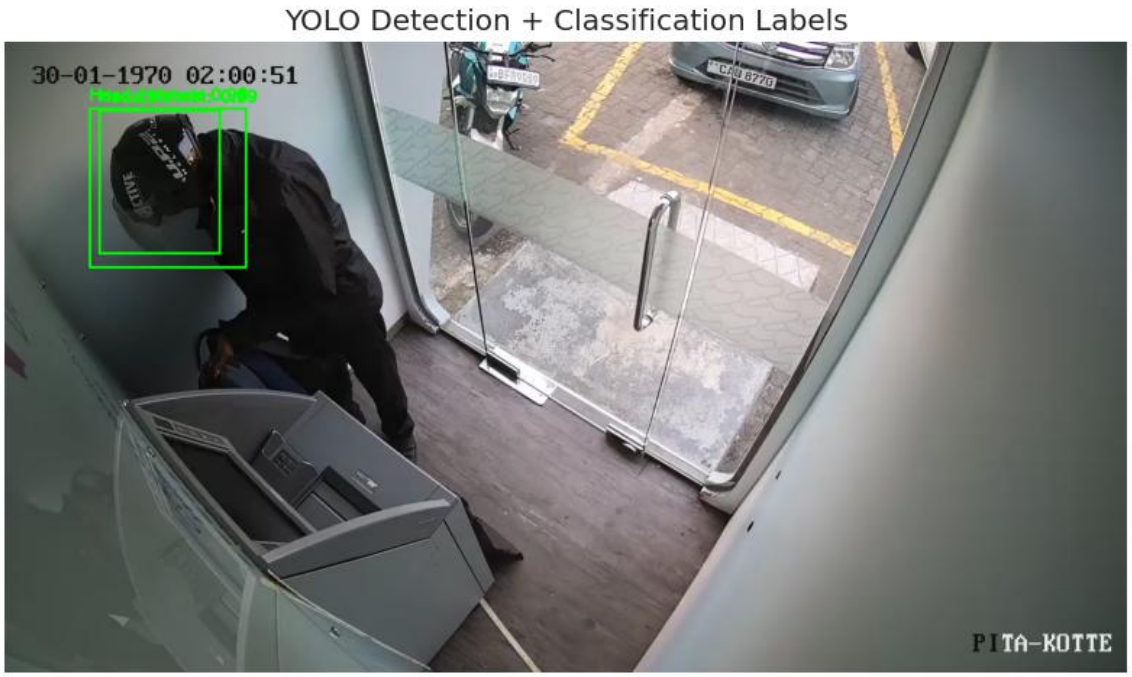

Figure 3: Object Detection and Classification

4. Conclusion

ATMs are critical financial access points but are frequent burglary targets due to their cash reserves and remote locations. Criminals often use helmets to conceal identities, rendering conventional surveillance ineffective. This study proposes an AI-based system for real-time helmet detection, utilizing a custom dataset of 718 CCTV images (574 training, 144 validation) to train an ensemble of YOLOv8 and MobileNetV2. While leveraging existing models, the system's novelty lies in its targeted application to ATM security, where it addresses a specific vulnerability (helmet-based identity concealment) through a low-power, cost-effective pipeline. The ethical creation of a tailored dataset and the system's ability to distinguish helmets from culturally significant headgear further enhance its practical and societal value. This solution is particularly impactful for standalone ATMs lacking on-site security, offering a scalable tool for intelligent surveillance while prioritizing privacy through responsible data handling.

Using CCTV footage, an ensemble deep network combines YOLO for object detection and head localization with MobileNetV2 for classifying headgear, distinguishing helmets from less occluding items like caps. The system issues on-screen warnings and real-time alerts to bank administrators via a web dashboard. Due to the lack of public datasets, CCTV images were manually labeled. The solution is especially useful for ATMs without security personnel. While effective, it raises privacy concerns, highlighting the need for responsible data use and rights compliance. Overall, the system provides an intelligent tool for strengthening ATM surveillance.

5. Implications and Future Work

The system demonstrates great promise for real-time helmet detection, thus fulfilling a significant ATM security void (Ji et al., 2022; Nair et al., n.d.). The recall of YOLO Mobile

should be enhanced and can be obtained by reducing the detection threshold, adding data augmentation techniques, or using a larger dataset (Wen et al., n.d.; Li et al., n.d.). Further improvement of MobileNetV2 could be accomplished using fine-tuning or experimentation on a larger and more diverse dataset to increase classification resilience (Patil et al., n.d.). Due to the limited dataset, methods such as transfer learning or synthetically generating data are recommended. Optimization of detection functionality, further dashboard integration, and comparison of deployment in various ATM environments will be part of future work (Nikouei et al., 2018; FBI, 2020).

6. Additional Future Directions Include

- **Ethical testing and bias mitigation:** Conduct fairness and bias audits across various demographic groups to ensure the system performs equitably and avoids unintended discrimination.
- **Dataset expansion:** Collaborate with banks and security agencies to collect a broader range of CCTV footage under legal compliance frameworks to improve generalizability.
- **Multi-feature detection:** Extend the system to support additional security features such as automatic face blurring for non-helmeted users (to protect privacy) and weapon detection for enhanced threat assessment.

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PERSONALITY-AWARE HYBRID SENTIMENT ANALYSIS WITH EXPLAINABLE AI FOR EARLY MENTAL HEALTH DETECTION ON FACEBOOK

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ABSTRACT

The increasing prevalence of depression and anxiety across the world has highlighted the dire need of scalable and early intervention devices which can be deployed outside of the usual clinical environments. The textual information posted by the users on social media, especially Facebook, is rich in terms of emotional states. But the majority of existing sentiment analysis models are Twitter- or Reddit-based and can be applied only to Facebook with its own specific content structure and user behavior. This paper suggests an innovative, text-based sentiment analysis framework of early identification of mental health problems on Facebook based on deep learning, personality trait modeling, and explainable artificial intelligence (XAI). We use BERT and *DistilBERT* models to extract textual features in a robust way and embed Myers-Briggs Type Indicator (MBTI) in order to contextualise individual differences in emotional expression. The proposed methodology uses existing labeled datasets, such as CLPsych and eRisk, to build initial models, and then such models are fine-tuned and validated on data collected in an ethically principled way with consent of Facebook users. LIME-based token attribution ensures explainability and enables clinician trust and real-world adoption. The anticipated results are the increase in the accuracy of detection compared to the classic models, the demonstration of the usefulness of personality-aware analysis and the creation of an understandable XAI dash in order to validate the research in the clinical setting. The contribution of this work is a strong platform-specific basis of digital mental health monitoring and the establishment of a multimodal extension in the future.

Keywords*: Text sentiment analysis, Mental health detection, Facebook dataset, personality traits, explainable AI.*

1. Introduction

Mental health disorders, including depression and anxiety, are a major cause of disability in every country globally, affecting society and economics, in general (World Health Organization, 2021). Although clinical diagnostics have improved, there are still barriers to it, namely, stigma, little access, and underreporting (Malhotra & Jindal, 2020). Social media networks have become an additional resource of unobtrusive monitoring of mental health, as most users share emotional discomfort in their posts (Yazdavar et al., 2020). Facebook, specifically, has a different atmosphere and lengthier, more intimate posts than Twitter or Reddit. However, most computational models for mental health detection are trained on Twitter data and may not generalize well to Facebook's linguistic and behavioral nuances (Shen et al., 2017; Hu & Flaxman, 2018).

Recent studies emphasize the fact that sentiment analysis would benefit by incorporating the aspect of personality, as the latter affects emotional manifestation as well as vulnerability to emotional disorders (Preoţiuc-Pietro et al., 2015). In addition, explainable AI (XAI) is gaining acceptance as a critical requirement of clinical adoption so that model outputs can be interpreted and trusted by practitioners (Lundberg & Lee, 2017). This paper seeks to fill these gaps by proposing a Facebook-oriented, text-based sentiment analysis system that includes personality characteristics and interpretability and uses not only publicly available labeled data but also those ethically gathered on Facebook.

2. Methodology

2.1. Research Design

This research adopts a supervised learning framework focused on text-based sentiment analysis for mental health detection. The approach is structured in two phases to model development using established labeled datasets, and platform-specific adaptation and validation using Facebook data.

2.2. Data Sources

- Public Labeled Datasets (Sourced from Kaggle and Benchmark Corpora):
    - Daily Dialogue Dataset: Emotionally annotated conversations, general sentiment and dialogue-based emotion detection.
    - Tweet Sentiment Dataset: Cross platform mental health cues Twitter posts that have been labeled by sentiment polarity.
    - Multiclass Depression Detection Dataset: Multi-class labeled data of different levels of depression severity.
    - Sentiment Dataset: General social media sentiment data, averaged to create emotion-classification baseline.
    - Reddit Depression Dataset: Reddit is an annotated post platform that tags depression indicators, which is characterized by longer text.
    - Depression Emo Dataset: Emotions that are associated with depression (e.g., sadness, hopelessness).

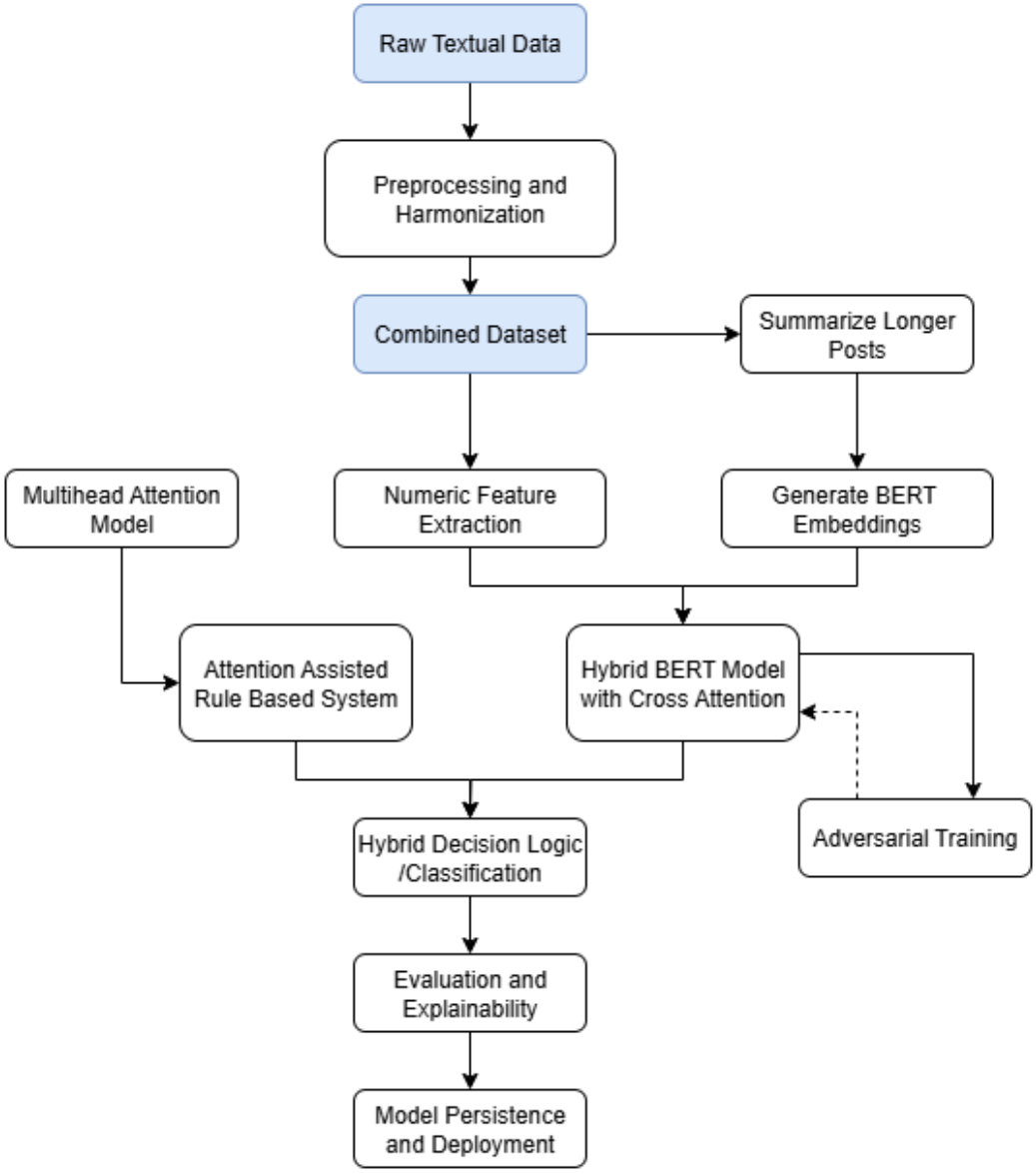

Figure 1: High-level Architecture Diagram

2.3. Tools and Analytical Methods

- Text Preprocessing:
  - Tokenization, normalization, removal of stopwords, and handling of Facebook-specific linguistic features.
- Feature Extraction:
  - *BERT-base-uncased*: Contextual embeddings for semantic understanding.
  - *DistilBERT*: For contextual embeddings and semantic understanding of text.
- Personality Trait Integration:
  - MBTI types collected via user survey, embedded as vectors and fused with text features.
- Classification:

    - Fully connected layers with softmax activation for multi-class prediction (e.g., high, medium, low).
- Explainable AI:
    - LIME values for token-level attribution, visualized for clinician review.
- Evaluation Metrics:
    - Macro-F1, AUROC, precision, recall, and clinical interpretability scores.

2.4. Rationale

The combination of BERT and *DistilBERT* leverages both contextual and sequential information, which has been shown to improve classification performance in mental health detection (Yazdavar et al., 2020; Shen et al., 2017). The use of established labeled datasets accelerates initial model development, while Facebook-specific fine-tuning ensures platform relevance. Personality trait integration addresses individual variability, and XAI supports clinical trust and adoption.

3. Results and Discussions

Expected Outcomes

- Accuracy Improvement:
    - Anticipated 7–10% improvement in detection accuracy on Facebook data compared to Twitter-trained baselines, consistent with prior multimodal and personality-aware studies (Malhotra & Jindal, 2020; Yazdavar et al., 2020).
- Personality Impact:
    - Integration of MBTI traits is expected to yield an additional 3–5% accuracy gain by personalizing emotional context (Preoţiuc-Pietro et al., 2015).
- Explainability:
    - LIME-based explanations will provide token-level insights, with expected clinician interpretability scores above 0.78.
- Platform-Specific Insights:
    - Analysis will reveal distinctive linguistic and emotional patterns in Facebook posts compared to other platforms, informing future model adaptation.

4. Discussion

This text-only solution is highly feasible and effective as it can be developed and validated very quickly, yet a clear pathway to multimodal extensions remains. The study fills the major gaps in the existing research by using public data sets and narrowing down to a Facebook-specific adaptation. The combination of personality traits and XAI is another feature of this work that provides theoretical and practical developments.

Table 1 Comparative Analysis with Existing Literature

Study	Platform(s)	Modalities	Personality	XAI	Reported F1	Limitations
Malhotra & Jindal (2020)	Twitter	text + image	None	None	0.78	small multimodal subset; no clinician validation
Yazdavar et al. (2020)	Twitter	text + image + network	None	Attention maps	0.81	crowd-sourced labels; imbalance bias
Shen et al. (2017)	Weibo	text	None	Bag-of-words	0.84 (Chinese)	unimodal; no privacy framework
MHA (2023)	Weibo	text + image	None	Hierarchical attention	0.87	lacks user-level PHQ-9 labels
ECA-Fusion (2025)	DAIC-WOZ (speech + text)	speech + text	None	Cross-attention	0.80 (utterance)	lab interview setting, not social media
Our Study (2025)	Facebook	text (+time)	MBTI	SHAP + Grad-CAM	-	small, opt-in, Facebook specific; MBTI validity concerns

5. Conclusion & Implications

The study presents a powerful, text-based model of pre-symptomatic mental health on Facebook that combines deep learning, personality modeling, and explainable AI. The strategy covers the most dangerous gaps in adaptations of platforms, personalization, and interpretability. Short-term effects are the increased accuracy of detection, the rise of clinical trust, and a scalable base of digital mental health tracking. This work will proceed to multimodal analysis, and longitudinal monitoring as a means of early intervention.

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FEDERATED LEARNING FRAMEWORKS FOR CLOUD PERFORMANCE: PRIVACY, COMMUNICATION, COMPUTATION AND SCALABILITY CHALLENGES

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ABSTRACT

Federated Learning (FL) is considered as a promising paradigm to enhance cloud computing performance by enabling decentralized model training mechanism while preserving data privacy. Its integration directly impacts on some critical domains including Privacy, Communication, Computational Performance and Scalability. A systematic literature review conducted through this study using academic databases such as IEEE Xplore, ScienceDirect and Research Gate. Approximately 10 open source and proprietary FL frameworks were analyzed with the aim of identifying strengths, limitations and operational challenges mainly across the four domains mentioned. The review identifies that most of the existing tools prioritize a particular domain, resulting in fragmented approaches that restrict comprehensive improvements cloud performance. Therefore, it concludes that there is a need for future research work focusing on developing multifunctional FL frameworks that address all the domains together. Also, it recommends that such frameworks would enable optimized, secure and scalable FL deployments.

Keywords: *Artificial Intelligence, Cloud Computing, Federated Learning, Machine Learning*

1. Introduction

In the context of digital transformation, cloud computing can be considered as a technology that offers scalable, flexible, and effective computing resources for different organizations. Cloud environments could benefit from integrating Artificial Intelligence (AI) and Machine Learning (ML) to improve system performance, operational efficiency, and responsiveness. These enhancements impact different domains, such as communication, scalability, privacy, and computational performance.

Federated Learning (FL) is a paradigm based on AI that allows decentralized model training while maintaining locality and data privacy. By implementing FL in cloud environments, different advantages can be granted, such as predictive optimization, intelligent resource allocation, autonomous workload distribution, improved real-time performance, and reduced bandwidth usage. With all these benefits, FL is capable of transforming conventional cloud architecture into a viable strategy with the aim of increasing system performance and encouraging innovation in a variety of organizations or fields.

Apart from the benefits provided, FL implementation presents different operational and technical difficulties. The challenges can be discussed under four main domains as communication, which manages the complexity of data exchange; scalability, which accommodates the large volume of participants; privacy, which deals with protecting sensitive data; and computational performance, which maximizes the limited cloud resources for effective training (Feng et al., 2025; Shenoy et al., 2025).

With the invention of FL, different FL frameworks have been developed with the aim of facilitating the deployment of FL applications, offering standardized functionalities along with enhanced usability (Riedel et al., 2024). Mainly focusing on the four main domains mentioned, this paper aims to conduct a systematic review of recent studies that discuss current federated learning frameworks by highlighting their operational challenges and technological issues and other main gaps. This paper also discusses the importance of implementing more secure and efficient federated learning frameworks in the future to be used within cloud environments to enhance their performance.

2. Literature Review

Federated Learning (FL) enables decentralized model training across multiple edge devices while preserving data privacy by using transformative frameworks in order to enhance cloud computing performance.

NVIDIA FLARE is a framework capable of emphasizing privacy and scalability but limited in adapting to various federated learning protocols which is a significant challenge for dynamic cloud-edge ecosystems(Schoenpflug et al., 2025). Additionally, some research demonstrates FL's potential to leverage distributed computing infrastructure without making any harm to sensitive data. For instance, FL's decentralized model training allows data to remain local on devices, thereby addressing stringent legal and ethical requirements concerning personal information privacy (Fachola et al., 2023). This decentralized approach inherently enhances privacy by minimizing raw data transfers and complements regulatory compliance frameworks. Privacy-preserving techniques remain an area requiring continuous

advancements. Frameworks such as PySyft and OpenFL integrated with basic privacy mechanisms, but the flexibility of such mechanisms has been limited. PySyft is limitedly use in practical applications due to some computational challenges while OpenML lacks in support for computation and scalability which narrows its usage scop in large-scale FL scenarios with diverse participants. Most of the FL systems are vulnerable to different defects which have not been effectively addressed and it demonstrates the need for strong security measure in distributed cloud environments (Yurdem et al., 2024).

In FL frameworks, communication remains a systematic challenge which directly impacts on performance and scalability. Flower and FATE (Federated AI Technology Enabler) open-source frameworks (Bagula et al., 2023.)focus on mitigating communication costs in distributed environment but encounter various challenges in managing heterogeneous data and client resource constraints. Such inefficiencies cause operational challenges in FL's role of improving cloud Quality of Service (QoS) aspects, including resource scaling, fault prediction, and load balancing. In order to handle cloud-based challenges such as system fault tolerance, FL can minimize administrative overhead and maximize computation performance by offering localized model updates (Malallah et al., 2023).

Computational performance is significant in heterogeneous environments. Frameworks such as FedML and FedScale work towards supporting different client capabilities and asynchronous FL models. But there is gap in efficiently managing client heterogeneity and developing robust communication protocols that support that accommodate varying network conditions and computational power. FedML also contains some issues in privacy implementations which needs improvement to meet data protection requirements(Riedel et al., 2024).

Scalability is also an important domain to concern under different frameworks capability. FederatedScope concentrates on FL use case but lack in general scalability and diverse communication protocol support(Riviera et al.,2023). It identifies that some common challenges such as efficiency, complexity and handling smaller datasets in current FL systems highlight the need of novel exploration to improve privacy and communication in FL frameworks. (Ogundokun et al., 2022).

Table 1: Summary of literature review

FL Framework	Hey gaps / limitations	Domain Focus
1. NVDIA FLARE (Schoenpflug et al., 2025)	Limited support for diverse FL variants and requires improvements in scalability.	Privacy, Scalability
2. Flower (Bagula et al.,2023)	Challenges in handling computation resources and has scalability issues with large node counts	Communication, Computational performance, Scalability
3. PySyft(Yurdem et al., 2024)	Need enhancements in privacy techniques, Limited computational efficiency	Privacy, Computational Performance

4. FATE (Bagula et al., n.d.)	Limited flexibility and requires better communication efficiency.	Privacy, Communication
5. OpenFL (Yurdem et al., 2024)	Focus on privacy but lack in supporting heterogeneous environments. Limited performance optimization	Privacy, Scalability
6. FedML(Riedel et al., 2024)	Gaps in privacy preservation mechanisms and need improvements in communication protocols.	Privacy, Communication, Computational Performance
7. FedScale(Elshair et al., 2024)	Support asynchronous FL but struggles with hilghly heterogeneous client devices and environments.	Communication, Computational Performance, Scalability
8. FederatedScope (Riviera et al.,2023)	Focus on vertical FL use cases, limited general scalability	Privacy, Scalability
9. Tensorflow FL (Mehdi et al., 2025)	Provides privacy preserving training but scalability remains constrained	Scalability, Privacy
10. Leaf (Riedel et al., 2024)	Lack built in privacy features	Scalability, Computational performance

Overall, current research directions prioritize balancing privacy with cloud computational efficiency, addressing scalability and heterogeneity in cloud federated environments, and enhancing security mechanisms (Mehdi et al., 2025). As in table 01 these reviews emphasize gaps and limitations which most of the frameworks has and it paves the way in demonstrating the importance of creating frameworks that are capable of handling all the instances based on these four domains.

3. Methodology

A comparative systematic literature review was conducted to analyze existing research on FL applications in cloud computing environments. The search was performed using multiple academic databases such as ResearchGate, IEEE Xplore, ACM digital library, Springer link and science direct. The search was primarily focused on reviewed articles published between 2020-2025 to ensure current relevance. The previous studies including federated learning implementations, evaluation methodologies for FL systems, privacy preserving mechanisms in distributed environments, analyzed communication efficiency and computation performance metrics, scalability challenges in cloud-based FL deployments were selected to enhance the capability of the review and non-related criteria were excluded. A total of 10 references were systematically selected and analyzed.

The existing evaluation approaches were structured into an analytical framework categorizing into four key dimensions as privacy preservation mechanisms, communication efficiency assessment, computational performance measurement and scalability evaluation. Privacy can be considered as a core advantage of FL particularly in sensitive domains such as healthcare,

finance and edge computing. Communication acts as a main domain in FL as it relies frequently on communication of model updates between clients and a central server. Computational performance can be efficiently increased by assessing different mechanisms such as CPU, RAM and training time based on FL deployments. Scalability can be used to assess whether a FL system can be continued with large volume of participants.

4. Results and Discussions

Federated learning (FL) enables decentralized model training that maintains sensitive data on local devices improving cloud computing performance and enhancing privacy without relying on centralized data storages. Current FL frameworks such as PySyft, FATE and openFL are able to handle privacy issues with their capabilities. FL faces challenges with scalability, communication overhead, and system complexity, especially when dealing with diverse and small datasets. Integrating emerging technologies such as blockchain shows promise for enhancing trust and auditability, but efficient communication protocols and managing complexity remain open research problems (Ogundokun et al., 2022). Discussing about FL implementation is not only relied on privacy but also rely on communication, computational performance and scalability.

Findings from the previous studies highlight that most of the current frameworks falls on the domain privacy where the need of developing frameworks based on other domains become efficient. It ensures that the FL implementation automatically enhances system performance specially when focusing on all these domains. Therefore, future research directions could be made to develop multifaceted frameworks which focuses on all the significant domains rather relying on a single domain.

5. Conclusion

Federated learning holds significant promise for enhancing cloud computing performance by enabling privacy-preserving, decentralized model training. The reviewed literature demonstrates that FL can optimize computational efficiency, resource management, and security within cloud environments. However, challenges related to scalability, communication overhead, and robust privacy-preserving techniques remain critical barriers to its widespread adoption. Multifaceted frameworks that strike a balance between security, performance, and privacy without sacrificing the quality of cloud services are needed to address these problems.

This review highlights the need for integrative FL frameworks, which balance privacy with scalability by offering a roadmap for optimized cloud deployments. By overcoming current gaps, federated learning can become a cornerstone technology for secure, efficient, and scalable cloud-based machine learning systems.

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DESIGN WITHOUT DESIGN: A CRITICAL REVIEW OF USER INTERFACE EFFECTIVENESS AMONG NON-DESIGNER IT PROFESSIONALS

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ABSTRACT

User interface (UI) design plays an important role in affecting the usability, accessibility, and overall user satisfaction of digital systems. However, in many development contexts, particularly within small teams or resource-limited environments, UI responsibilities are handled by IT professionals without formal design training. Despite the availability of UI/UX guidelines, only few researches examine how effectively non-designers apply them or whether their interfaces meet user expectations. This review evaluates how limited design literacy affects the quality of UIs developed by non-designer IT professionals. Using a thematic analysis of prior literature, the study identifies recurring challenges such as reliance on templates, insufficient application of visual principles, weak feedback mechanisms, and limited iterative testing. Although these systems are often technically functional, they frequently fail to provide user-friendly interaction, emotional engagement, or accessibility across multiple user contexts. The findings emphasize the need to embed design literacy in IT education and to promote collaborative models that integrate design expertise into development. Furthermore, the review highlights that emerging AI-powered tools create an "AI literacy paradox": while they advanced development, they risk discouraging IT professionals from developing essential human-centered design skills. Addressing these challenges requires not only curriculum reform but also stronger interdisciplinary collaboration to ensure future interfaces are functional, inclusive, and engaging.

Keywords: *User Interface (UI), User Experience (UX), Design Literacy, Non-Designers, Visual Communication*

1. Introduction

In modern digital development environments, user interface (UI) design is no longer a supportive role but a primary factor of user satisfaction, system usability, and accessibility. However, UI responsibilities are frequently undertaken by IT professionals who lack formal training in visual communication or user-centered design. This trend highlights a recurring gap between technical expertise and design literacy, a disconnect that raises critical questions about the quality of user experiences produced without formal design training or education. This gap raises not only usability concerns but also questions about professional identity: should IT specialists without design training be responsible for shaping user experience?

Although the growing number of user-friendly UI developers, pre-designed layouts, and guidelines have made interface design more accessible, they do not cover the deeper cognitive, visual, and design principles essential for creating user-friendly systems. As mentioned in the existing literature, many interfaces developed by non-designer IT professionals exhibit functional effectiveness but lack user-friendliness, particularly in terms of visual hierarchy and user engagement. A well-designed interface with organized documentation increases user satisfaction and creates a pleasurable experience. This facilitates knowledge and skill development and prevents user frustration Toivanen (2024). As Norman (2013) notes, it is when the disciplines operate independently of one another that major clashes and deficiencies occur. Usability issues, including limited functionality, interface complexity, and lack of documentation, were also highlighted by some participants, although these difficulties were encountered less frequently. This implies that while platforms are generally considered user-friendly, there are still areas where persistent gaps can benefit from an improved user experience Toivanen (2024). Consequently, the effectiveness of interfaces designed by non-designer IT professionals is a challenging discipline, where the absence of formal design literacy must be acknowledged.

This study critically investigates how the lack of design education or training among IT professionals affects the usability, accessibility, and visual design quality of the user interfaces they produce and the user experience. Through an analysis of development in the previous literature and common limitations in such interfaces, this review identifies the need for design-centered development models and enhanced design education in IT curricula.

2. Methodology

This critical review adopted a qualitative thematic approach to examine the effectiveness of user interfaces designed by IT professionals without formal design education. This method was selected because it allows combination of multiple scholarly findings and practitioner experiences in a field with limited experimental investigation. Literature was collected from well-established scholarly databases and industry publications, focusing on UI design principles, usability engineering, and the role of non-designers.

Sources were selected based on relevance to UI/UX design, usability, and the role of non-designers, ensuring coverage of both classic theory and recent developments. Key works by Jakob Nielsen (1993) and Norman (2013) provided a theoretical foundation for evaluating

usability and design effectiveness, emphasizing user-centered design and highlighting common challenges in interfaces built by non-designers.

Articles from the Interaction Design Foundation were also used to frame the role of UI and UX principles, stressing clarity, consistency, and visual hierarchy in interface design. These insights informed the thematic analysis, which examined recurring interface deficiencies and evaluated how effectively existing UI/UX guidelines and automated tools address or compound usability issues. This approach enabled a critical perspective on the relationship between technical expertise and design literacy, with implications for collaboration between designers and IT specialists.

3. Results and Discussions

The analysis of existing literature reveals a persistent systemic gap between technical proficiency and design literacy among non-designer IT professionals. While the systems they develop are often technically functional, they consistently fall short in usability, accessibility, and meaningful user engagement. This reflects not only isolated mistakes but also broader weaknesses in IT education, which emphasizes coding efficiency while neglecting visual communication, cognitive principles, and user-centered design.

As summarized in Table 1, recurring usability issues include the overuse of templates, poor color harmony, lack of feedback mechanisms, weak visual hierarchy, and limited iterative testing. These patterns show that while low-code platforms and prebuilt templates improve development speed, they also produce generic and uninspiring interfaces Toivanen (2024). Importantly, the evidence suggests that usability failures stem not only from technical shortcuts but also from fundamental gaps in design literacy. Thus, the table highlights systemic weaknesses rather than random flaws, underscoring that efficiency-driven development without critical design thinking results in predictable and recurring usability problems.

Table 1 Common Usability Issues Identified in Reviewed Studies

Usability Issue	Key Impact	Source(s)
Overuse of templates	Generic, uninspiring interfaces	Toivanen (2024)
Poor color harmony	Reduces clarity and emotional appeal	Qahman et al. (2021); Niemi (2025)
Lack of feedback	Violates usability heuristics	Nielsen (1993)
Weak visual hierarchy	Low readability and comprehension	Norman (2013)
No iterative testing	Ignores evolving user needs	Alomari et al. (2020)

AI-powered tools advance development and reduce technical barriers, but they also shift responsibility from human empathy to algorithmic defaults. This creates an AI literacy paradox: although AI democratizes design, it may discourage IT professionals from developing deeper design sensibilities, prioritizing efficiency over empathy and creativity. As Teixeira & Braga (2025) argue, this shift represents a move “from empathy to algorithms,” raising

concerns about whether future interfaces will reflect human-centered values or automated outputs.

A closer look at visual literacy exposes further weaknesses. Non-designers frequently struggle with color harmony and contrast Qahman et al. (2021), which undermines both clarity and emotional engagement. Such failures are particularly damaging in mobile contexts, where visual clarity and trust directly affect usability. The repetition of these issues suggests systemic educational gaps, as even basic visual communication principles are overlooked in technically focused IT training. Rather than being isolated mistakes, these design errors demonstrate how the absence of visual literacy disrupts readability, weakens trust, and reduces user satisfaction.

Finally, the persistence of these problems can be framed through established usability theories. Nielsen's heuristics, particularly feedback and visibility of system status, continue to be widely violated in non-designer-built systems Nielsen (1993). Norman (2013) emphasizes that effective design becomes invisible when it works seamlessly yet in interfaces created by non-designers, design flaws are highly visible and disruptive. These repeated violations demonstrate that, despite decades of research and the availability of tools, fundamental usability principles remain absent from IT curricula. Collectively, the findings highlight that bridging the design literacy gap is essential for improving user experience, accessibility, and the overall quality of digital interfaces.

4. Conclusions

This review demonstrates that a significant design literacy gap persists among non-designer IT professionals, resulting in recurring usability challenges despite technical proficiency. Core issues such as poor visual hierarchy, ineffective color use, and weak application of usability heuristics reveal that technical training alone cannot ensure user-centered outcomes.

While low-code tools, templates, and AI-powered platforms can accelerate development and provide baseline usability, overreliance on them leads to generic, uninspiring, and often inaccessible interfaces. Their value lies in supporting, not replacing critical design thinking. Without sufficient design literacy, these tools amplify weaknesses rather than solving them.

Bridging the design literacy gap is essential to ensure that future digital systems are not only functional but also inclusive, engaging, and human-centered. To address this gap, IT education must integrate foundational training in usability, visual communication, and emotional design, alongside emerging competencies such as AI literacy. Moreover, interdisciplinary collaboration between IT professionals and trained designers is essential to develop interfaces that are functional, inclusive, engaging, and trustworthy. Integrating human-centered design processes, iterative testing, and feedback loops will be critical for moving beyond purely functional systems toward meaningful user experiences.

Future research should focus on developing comprehensive IT curricula that systematically incorporate these design principles and interdisciplinary practices, equipping the next generation of professionals to create digital systems that are both technologically advanced and human-centered.

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A DIGITAL PLATFORM FOR OPTIMIZING RAW MATERIAL DISTRIBUTION IN SRILANKA

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ABSTRACT

Due to logistical bottleneck and volatile supply chain, this research is dedicated to develop a digital platform designed to intelligently optimize the distribution of raw materials across Sri Lanka, transforming the fragmented system into an unified, efficient, and transparent national asset. The procurement process, wastage reduction, and availability of essential materials are been streamline through this platform. The objective of this study critically reviews the literature in optimizing raw material distribution in Sri Lanka based on a sample of 50 papers published within the duration of 2021 to 2025. A comprehensive analysis of various factors caused due to mismanagement of raw materials and how the digital platform can overcome these issues has been presented throughout the paper. The methodology involves in designing a web-based system featuring user logins, real-time stock changes, online ordering, Geo location tracking, predict future trends, and demand forecasting. The system will be tested with a pilot group of suppliers and buyers in Sri Lanka to evaluate the effectiveness of the system. Improved access to supplies for buyers, decrease in raw material wastage, enhance profitability for suppliers are the expected results from the system. The study concludes with recommendations for scaling the platform. The findings emphasize that the digital transformation in the raw material supply chain show great promise in improving country economy and reduce wastage in Sri Lanka.

Keywords: *Supply chain optimization, Raw material distribution, web-based system, Perishable and non-perishable goods, Trends and demand prediction AI system, Sri Lanka*

1. Introduction

The primary objective of this research is to pioneer a resilient digital ecosystem for Sri Lanka that leverages real-time data and predictive analytic to revolutionize raw material logistics. Our aim is not merely to improve distribution but to forge a smarter, more adaptive supply chain capable of fueling sustainable industrial growth and competitive advantage on a global scale.

A significant economic loss has been raised due to the mismanagement of raw materials in Sri Lanka particularly in the sector of perishable goods and shortage in non-perishable goods. This study helps to build a bridge between suppliers and buyers, ensuring efficient resource utilization through a digital solution. Through the digital solution we can bridge the gap for buyers to access high quality raw material for efficient production. The inefficiency in raw material distribution, particularly in developing countries like Sri Lanka, has been widely studied and has highlighted two key issues; as wastage of perishable goods (e.g., agricultural goods, dairy, flowers) due to poor supply-demand matching and shortage of non-perishable materials (e.g., construction, textile) caused by fragmented supply chains (*Report*, n.d.). According to reports it shows Sri Lanka's supply chain faces various challenges including infrastructure limitations, customs procedures, and economic disruptions. 200+ projects were delayed due to cement shortage and 60% of construction firms reported "inefficient supplier networks". Sri Lanka ranks 94th globally in logistic efficiency, due to bottlenecks in supply chain. Rice prices spiked by 80% in 2022 due to boarding and import delays. In the study conducted by the international congress by Gustavsson (Gustavsson et al.,2011), shows that billions tons of food per year is wasted globally due to mismanagement in raw material supply chain. The literature review highlights similar successful implementations (e.g., India's eNAM, Alibaba Agri) emphasizing the role of technology in supply chain optimization. A supply chain of one's company cannot withstand a sudden demand, challenging the business to produce large stock or services with the limited suppliers which we came across during the pandemic years (Cohen et al., 2020). With right chain optimization the door to expand the suppliers and streamline the business operations are a breeze, without being bottle necked to one small group of suppliers (*Global Supply Chain Barriers*, n.d.). Construction sector frequently faces low supply of raw materials due to poor supply chain and not being able to reach to best or efficient raw materials. With a digital solution, raw material supply can be streamlined with a breeze ensuring quality on-time projects (MaterialFlow, 2024). It is just not for non-perishable good but, also in the aspect of perishable goods 1.3B tons/year of food lost globally, with developing nations losing 40% post-harvest due to poor storage, while developed nations waste 35% at retail/Consumer level (Gustavsson et al. 2011). Being not able to transport or find buyers causes poor cold storage and transportation networks contribute to 30-40% post-harvest losses in perishable goods (FAO, 2020). Highlights 30-40% losses in Sri Lanka's fisheries from inadequate refrigeration (infofish org et al., 2023). With the consideration of these persistence issues it documents 25% spoilage reduction in food market using block-chain and IoT, through high upfront cost limit scalability (Matraeve et al. 2024). With an AI-driven closed loop system, showing 15-20% waste reduction via government incentives for recycling (Guo et al. 2025). The Middleman-domination reduce farmed profits; therefore, a digital platform could shorten supply chain by 15%. However, limitations persist in low digital literacy in rural areas and infrastructure gaps. This study is built on these insights to design a context-aware platform for Sri Lanka.

2. Methodology

This study employs to address Sri Lanka's supply chain gap combining data collection and analysis to capture a comprehensive understanding on the overcoming raw material supply chain using a digital platform. The analysis consists of 50 papers including Reports, news articles, journals, conference papers, assessments from 2021 to 2025, and examining references used by the authors. Within a large amount of resources, the best 15 resources are scraped out to write this study.

3. Results and Discussions

The data collected during this study shows that the perishable and non-perishable goods go on wastage or lacks in supply due to poor management in supply chain. Perishable good such as vegetable, fruits, fish, and flowers go wastage due to low cold storage, in the other hand buyers lose customers for not having enough supply due to the hindrance of unrecognized connections. Non-perishable goods like cement, tiles, materials for crafting etc. cannot find buyers or buyers cannot spot sellers due to the unrecognized connections. Causing loss of new startups, customers in old business, low quality projects. With Proven digital system used in developed countries, overcoming the raw material distribution with a digital platform can increase the business and customer satisfactory rates, more exports create a stable and sustainable economy for the country and reduce the poverty of the country reaching the status of 'developed country'. With the proposed digital system, the streamline of raw material supply chain can be achieved through connecting suppliers and buyers and using AI technology to predict trends in different sectors helping businesses to produce goods or services accordingly without over-producing or under-producing. With analytic reports, businesses can plan the product manufacturing processes accordingly to the trends in before-hand. Below table show case issue addressed by the researches and a solution idea proposed.

Study	Good Type	Issue Addressed	Solution Proposed
Dong (2022)	Raw materials	Inefficiencies in raw material supply chain	AI based system
Ariyawansa et al. (n.d.)	Fisheries in Sri lanka	Postharvest loss	Improved handling, storage and policy interventions
Guo et al. (2025)	Closed-loop supply chains	Government incentives and sustainability in supply chain	Deep learning-based AI model
Gustavsson et al. (2011)	Global food supply	Food loss and wastage in supply chain	Logistic and Strategies for prevention, better storage
Matraeva et al. (2024)	Wholesale food markets	Lack of digital ecosystems in food supply chains	digital platforms for efficiency

The World Bank (n.d.)	Global trade	Inefficiencies in supply chain logistics	Policy reforms and infrastructure improvements
The World Bank (2013)	Global trade	Supply chain barriers	Reducing trade logistics barriers
Herath et al. (2024)	Sri Lankan exports	Supply chain resilience	Strategies for resilient and sustainable trade
Seneviratne & Weerasinghe (2024)	Tea (Sri Lanka)	Inefficiencies in tea export supply chains	Process optimization and stakeholder coordination
Trojahn & Strubelt (2020)	Raw materials	Profitability and sustainability in supply chains	Data-driven optimization and sustainability integration
Fernando et al. (2023)	Tea (Sri Lanka)	Upstream supply chain inefficiencies	Policy reforms, technology adoption, and farmer support

4. Conclusions

The analysis of Sri Lanka's supply chain, supported by global evidence from World Bank, FAO, and an academic research, implies the critical role of logistic efficiency, technology integration, and policy intervention in driving economic growth, sustainability and resilience. Inefficient supplier-buyer coordination can be overcome with real time inventory tracking and demand forecasting system reducing both spoilage and stock out. With Geo-location-based routing can cut delays by 30-50% in supply chain disruptions and inflation can be over-come with transparent digital marketplace. More direct supply from local farmers, raw material production, cutting down middleman cost in production, good price for the suppliers, open doors for startups to sell and buy raw materials with ease can be archived through the digital platform. Which help in country's economy level increment and reduce wastage in stocking raw materials without buyers. The digital system allows production companies to have continuous supply of raw materials and small-scale raw material suppliers are recognized leading to a balance economy. Future researches like advocate for government partnership to scale the solution. The study generalizes that the proposed system is a saleable and efficient solution to Sri Lanka's supply chain.

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CHALLENGES FACED BY BILINGUAL TEACHERS IN THE TEACHING – LEARNING PROCESS

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ABSTRACT

Sri Lanka's Bilingual Education Policy (BEP), launched in 2001 to promote social cohesion and competitiveness, has yet to achieve equitable implementation, particularly beyond urban centers. This study investigates the teacher-level challenges that undermine bilingual pedagogy in the Negombo Education Zone, addressing the persistent gap between policy and practice. A convergent mixed-methods design was adopted, combining questionnaires from 30 bilingual teachers with semi-structured interviews of two Zonal Education Directors, supplemented by secondary data. Findings reveal a paradox: while 94% of teachers are academically qualified, most lack systematic preparation in bilingual pedagogy. A majority received their own schooling in the mother tongue and have limited exposure to Content and Language Integrated Learning (CLIL), leaving them ill-equipped to balance subject and language demands. This reflects Cummins' (2000) distinction between Basic Interpersonal Communication Skills (BICS) and Cognitive Academic Language Proficiency (CALP). The absence of mentorship structures and inconsistent use of teaching resources further hinder scaffolding within Vygotsky's Zone of Proximal Development (ZPD). At the same time, strong parental and student motivation emerged as an underutilized strength. The study concludes that BEP stagnation arises less from policy design than from systemic failures in teacher preparation and institutional support. Recommendations include a national teacher development framework, mandatory CLIL-based certification, and institutionalized mentorship systems. Mobilizing community support could further strengthen accountability. These findings align with international evidence that effective bilingual education depends on sustained teacher training and supportive ecosystems (May, 2016; Son & Kim, 2024).

Keywords*: Bilingual Education, Professional Development, Content and Language Integrated Learning (CLIL)*

1. Introduction

Learning subject matter rather than the target language directly has been found to be more effective in second language acquisition (Medawattegedera, 2015). Bilingual education, broadly defined as the use of two languages as mediums of instruction, has been implemented in diverse forms worldwide (Andersson & Boyer, 1970; García, 2009). Models include transitional, developmental, and immersion programs (Mahawattha, 2012). In Sri Lanka, the Bilingual Education Policy (BEP) was introduced in 2001 through Amity Schools, adopting a developmental model where English is used for selected subjects such as Science, Mathematics, and Geography from Grade 6 onwards (National Education Commission, 2003). The policy aimed to foster social cohesion and global competitiveness by enabling students to achieve proficiency in both their first language (Sinhala/Tamil) and English.

However, research highlights a persistent policy practice gap. Students in bilingual streams often struggle with academic English proficiency (Mahawattha, 2012), echoing Cummins' (2000) distinction between BICS and CALP. International evidence confirms that effective bilingual programs depend on specialized pedagogical training, particularly in CLIL (Coyle, Hood, & Marsh, 2010; May, 2016). Teacher preparedness in Sri Lanka remains limited, and program expansion has been uneven, favoring urban schools (Mahawattha, 2012).

This study, therefore, focuses on bilingual teachers as central agents of policy implementation. Guided by Vygotsky's (1978) ZPD, it investigates systemic supports or the lack thereof that enable teachers to scaffold both content and language learning.

1.1. Research Questions

1. What academic and professional qualifications do bilingual teachers possess?
2. Do bilingual education teachers receive adequate exposure to English-medium learning?
3. What is the scope and content of training provided to bilingual teachers?
4. How available and accessible are bilingual teaching resources?
5. What mentorship structures exist to support bilingual teachers?
6. To what extent do stakeholders provide support for bilingual education teachers?

By situating the Sri Lankan experience within international research on bilingual education (Odacıoğlu & Uysal, 2016; Son & Kim, 2024), this study seeks to explain why BEP continues to face stagnation and how teacher capacity-building could bridge the policy–practice divide.

2. Methodology

A convergent mixed-methods design was employed to capture both the prevalence and lived experiences of bilingual teacher challenges (Creswell & Plano Clark, 2011).

Sample and Sampling: Participants included 30 bilingual teachers from the Negombo Zone and two Zonal Education Directors. Purposive sampling ensured representation across Ja-Ela, Negombo, and Katana divisions. While limited in scale, this approach allowed in-depth exploration of teacher challenges.

Data Collection:

- Quantitative data were gathered through structured questionnaires (Google Forms) with closed and open-ended questions.
- Qualitative data were collected via semi-structured interviews with directors.
- Secondary data included student exam results, Ministry circulars, and census reports.

Data Analysis: Quantitative data were analyzed using descriptive statistics (frequencies, percentages). Qualitative data were thematically coded, guided by Cummins' BICS/CALP and Vygotsky's ZPD. Integration through triangulation enhanced validity.

Limitations: The study is geographically limited to Negombo and constrained by a small sample size. COVID-19 necessitated replacing classroom observations with online lesson reviews, limiting direct insights into classroom practice.

3. Results and Discussions

Although 94% of teachers hold degrees, 93% were educated in L1 and only 10% hold PGDE qualifications. This undermines their ability to deliver CLIL-based instruction. Similar findings appear in Sri Lanka (Mahawattha, 2012) and globally (May, 2016). Directors acknowledged that "nobody takes responsibility" for mentoring. This gap leaves novice teachers unsupported, confirming international concerns about fragmented professional development in bilingual contexts (Odacıoğlu & Uysal, 2016). Resource use is inconsistent: 47% report frequent use, while 27% use materials only sometimes. Reliance on note-taking reflects teacher-centered approaches that fail to scaffold learning, contrary to Vygotsky's ZPD framework. Similar limitations are noted in Sri Lankan bilingual classrooms (Mahawattha, 2012) and in international contexts (Son & Kim, 2024). Nearly half (47%) of teachers reported strong parental involvement, reflecting a valuable but underutilized asset. As García (2009) argues, community engagement is critical for sustaining bilingual education.

Table 1: Key Findings

Domain	Finding	Evidence	Implication
Professional Preparedness	Qualified but lacking bilingual pedagogy training	93% schooled in L1; <10% PGDE	CLIL and CALP instruction underdeveloped
Systemic Support	No mentorship structures	Director interviews	Novice teachers unsupported; burnout risks
Classroom Pedagogy	Reliance on note-taking; inconsistent resources	47% frequent use; 27% sometimes	Weak scaffolding; limited ZPD support
Stakeholder Engagement	Strong but passive parental support	47% report active involvement	Untapped potential for advocacy and improvement

4. Conclusions and Recommendations

This study concludes that BEP stagnation is rooted in systemic shortcomings rather than teacher or policy flaws. Teachers are academically qualified but pedagogically underprepared, lacking training in CLIL and professional mentorship. Resource use is inconsistent, while strong parental support remains unleveraged.

Recommendations:

1. **National Teacher Development Framework** - Address the 93% of teachers educated in L1 with a structured framework for recruitment, pre-service, and continuous training.
2. **Mandatory CLIL Certification** - Integrate CLIL pedagogy into all teacher training programs to develop bilingual teaching competencies.
3. **Mentorship and ISA Roles** - Establish formal mentorship and zonal In-Service Advisors to address the systemic absence of guidance.
4. **Enhanced Resource Provision** - Provide consistent teaching-learning materials and training for scaffolding bilingual instruction.
5. **Mobilizing Stakeholders** - Convert strong parental support into active advocacy for teacher development and resource investment.

Limitations: Findings are restricted to one zone, with limited sample size, and reflect adaptations required during COVID-19. Results should therefore be viewed as context-specific rather than universally generalizable.

Conclusion: Bilingual education's transformative potential in Sri Lanka depends on strategic teacher capacity-building. Investing in CLIL-based training, mentorship, and institutional support while leveraging strong community backing offers the most viable pathway for bridging the policy–practice divide.

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BARRIERS AND ENABLERS TO CLASSROOM-BASED SUPPORT FOR DYSLEXIC LEARNERS: A QUALITATIVE STUDY OF PRIMARY TEACHERS IN SRI LANKA

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ABSTRACT

Despite growing international recognition of the importance of early intervention in dyslexia, Sri Lankan primary education continues to exhibit systemic neglect toward supporting affected learners. While global research emphasizes the role of teachers in early identification and inclusive instruction, little is known about how Sri Lankan teachers interpret and respond to dyslexia in practice. This study investigates the multifaceted barriers and enabling conditions that shape classroom-based support for dyslexic learners in Sri Lankan primary schools. Using a triangulated qualitative approach; teacher questionnaires (117 schools), semi-structured interviews with education administrators, and a cross-disciplinary panel discussion, the research reveals a layered interplay of conceptual misunderstandings, limited pedagogical training, institutional inertia, and emotional labor. Frith's (1995) causal model of dyslexia was applied to interpret the disconnect between biological-cognitive understandings and classroom-level responses. This research fills a critical gap in understanding not only what Sri Lankan teachers believe about dyslexia, but also how they act or fail to act within real classroom constraints. Recommendations include integrating neurocognitive literacy into teacher training, establishing school-based literacy labs, formalizing referral systems, and promoting teacher-led professional networks. By shifting the policy lens from awareness to action, this study aims to build capacity for inclusive, context-sensitive support for dyslexic learners.

Keywords: *Dyslexia, Teacher Beliefs, Inclusive Education, Sri Lanka, Primary Schools, Frith's Model*

1. Introduction

Dyslexia, a specific learning disorder that disrupts reading fluency, phonological awareness, and spelling, affects 5% to 10% of school-aged children worldwide (Shaywitz, 2005). Despite this high prevalence, many learners; particularly in low-resource educational settings remain unidentified and unsupported. While international frameworks increasingly call for early intervention and inclusive pedagogies, Sri Lanka has yet to adopt systemic mechanisms to identify and support dyslexic learners at the primary level (Indrarathne, 2019).

Although most Sri Lankan primary teachers report encountering students who consistently struggle with literacy, they often lack the knowledge, training, or institutional guidance to respond effectively. Prior local studies (Hettiarachchi, 2021; Peries et al., 2021) have revealed widespread misconceptions about dyslexia's causes and symptoms. However, these studies have primarily focused on teacher beliefs and knowledge. What remains largely unexplored is how teacher beliefs and knowledge translate into classroom practices, and how systemic and contextual factors either enable or hinder effective support for dyslexic learners.

This study responds to that gap, by exploring "what barriers and enabling factors shape the ways Sri Lankan primary school teachers identify and support dyslexic learners within classroom settings?" Using Frith's (1995) causal model as an interpretive lens, it seeks to uncover the conceptual, systemic, and emotional dynamics that shape teacher behavior. Through an exploration of both obstacles and enablers, this research aims to generate actionable insights to inform inclusive policy and practice in Sri Lankan education.

1.1. Research Objectives

This study aims to:

- Identify the classroom-level barriers faced by Sri Lankan primary teachers in identifying and supporting dyslexic learners.
- Explore informal or adaptive practices that act as enablers of inclusive classroom support.
- Recommend context-sensitive strategies and systemic interventions to build capacity for dyslexia-responsive education.

1.2. Literature Review

International research consistently highlights that teacher understanding plays a pivotal role in early dyslexia support. Misconceptions such as associating dyslexia with laziness or visual deficits persist even among trained professionals (Fowler, 2024; Washburn et al., 2013). Washburn (2013) et al. found that many pre-service teachers in the US believed dyslexia was primarily visual, rather than phonological. Similarly, Knight (2018) notes that uncorrected misconceptions often lead to ineffective or absent interventions.

In the Sri Lankan context, Hettiarachchi (2021) and Peries et al. (2021) observe that while many teachers suspect learning difficulties in their students, they often lack the confidence or institutional support to act. Misattributions such as blaming home environments or labelling

students as lazy frequently override cognitive or neurological explanations. Indrarathne (2019) further highlights that even when teachers are sympathetic, they are constrained by rigid curricula, large class sizes, and an absence of formal diagnostic or referral systems.

Yet the literature also indicates potential entry points for change. Some teachers pursue informal learning through NGO workshops, peer mentoring, or self-study (Fowler, 2024). These grassroots adaptations show that despite systemic limitations, teacher agency can serve as a powerful enabler when properly supported. This study builds on these findings by examining not only what Sri Lankan teachers know or believe, but also how they navigate real-world classroom and institutional constraints.

2. Methodology

This qualitative study employs a triangulated design to explore teachers' lived experiences and the practical realities of supporting dyslexic learners within mainstream primary schools. Three complementary data sources were used:

- **Questionnaires** were distributed to 60 primary teachers across 117 schools within a selected education zone. These schools were chosen to capture a diverse cross-section of institutional contexts including urban, semi-urban, and rural settings; thereby providing a representative sample of the wider primary education system and allowing the findings to reflect broader patterns.
- **Semi-structured interviews** were conducted with educational administrators, including teacher educators, school principals, and subject directors. These interviews aimed to capture systemic perspectives on policy, training, and resource gaps related to inclusive education.
- **Panel discussions** brought together five teachers from special education units and five mainstream primary teachers. These sessions facilitated a comparative, cross-practice dialogue about institutional enablers, barriers, and opportunities for collaboration.

Triangulation was implemented by systematically comparing findings across the three methods. Questionnaire results highlighted general patterns of teacher knowledge and practice, while interviews provided institutional and systemic perspectives, and panel discussions revealed dialogic insights into how mainstream and special education teachers perceive and negotiate barriers. Findings largely converged in identifying gaps in training and systemic support, though some divergence emerged around the extent of teacher agency, with administrators emphasizing systemic constraints while teachers highlighted informal strategies. These differences were treated as complementary, enriching the overall interpretation and ensuring a more nuanced understanding of the issue.

Data analysis followed a thematic coding process. Codes were grouped under five domains: conceptual, pedagogical, systemic, emotional, and resource-based. To examine how responses aligned with Frith's (1995) causal model. This framework allowed a layered interpretation of how teacher knowledge translates into action or inaction.

Coding reliability was enhanced through a peer review process. Inter-coder agreement was calculated at 87%, with discrepancies resolved through discussion, thereby strengthening the consistency and trustworthiness of the thematic analysis.

3. Results and Discussions

The study revealed that primary teachers in Sri Lanka hold a blend of conceptual confusion, institutional limitations, and emotional tension in relation to dyslexic learners. At the same time, teachers demonstrated resilience, empathy, and adaptive creativity in their classrooms. Interpreted through Frith's causal model, these findings show how gaps at the biological and cognitive levels of understanding cascade into behavioral responses within the classroom. Conversely, enabling conditions highlight points where teachers' agency can bridge or mitigate these gaps.

3.1 Barriers to Classroom-Based Support

Conceptual Misunderstandings

A major barrier identified was widespread misinterpretation of dyslexia. Many teachers equated dyslexia with general academic underperformance or behavioral problems. Panel discussions revealed that terms such as "lazy" or "unmotivated" were used to explain students' struggles, reflecting a failure to recognize the cognitive basis of dyslexia. Similarly, attributing poor reading to inadequate parental involvement reduced the problem to a social or environmental issue, ignoring the biological–cognitive underpinnings highlighted in Frith's model (Shaywitz, 2005). This illustrates a disconnect between teachers' conceptual framing and the neurological reality of dyslexia.

Pedagogical Limitations

Teachers reported little exposure to inclusive teaching methods or targeted literacy interventions. Heavy syllabi and exam pressures constrained their ability to adapt instruction, often resulting in rote learning or disciplinary measures. Within Frith's model, this reflects a gap in translating cognitive-level understanding of phonological deficits into behavioral-level classroom strategies. Without training in structured literacy or evidence-based interventions (Washburn, Binks-Cantrell, & Joshi, 2013), teachers struggled to act on the neurocognitive needs of dyslexic learners.

Systemic Constraints

Overcrowded classrooms, lack of specialized staff, and the absence of referral mechanisms left teachers feeling powerless to individualize support (Peries et al., 2021). From Frith's perspective, these are behavioral-level barriers: even if teachers suspected cognitive difficulties, the systemic environment constrained their capacity to respond through meaningful classroom action.

Emotional and Social Barriers

Teachers highlighted the risks of labeling students as dyslexic, fearing stigma, parental backlash, or accusations of professional inadequacy. This emotional discomfort contributed to avoidance of direct intervention. Here, Frith's model underscores how behavioral-level responses (avoidance, hesitation) are shaped not only by knowledge gaps but also by socio-emotional pressures embedded in the school culture (Knight, 2018; Hettiarachchi, 2021).

3.2 Enablers of Classroom-Based Support

Personal Motivation and Empathy

Despite systemic challenges, teachers showed strong personal commitment to supporting struggling learners. Their empathy reflects a behavioral-level enabler in Frith's model, although their biological and cognitive understanding was limited, they acted fostering student inclusion.

Informal Training and Peer Exchange

Workshops run by NGOs or peer mentoring provided teachers with practical tools such as phonics-based instruction or multisensory approaches. These interventions directly linked cognitive-level insights (phonological processing, multisensory learning) to behavioral-level classroom practices, showing that even modest training can help teachers operationalize neurocognitive principles.

Adaptive and Intuitive Practices

Teachers independently introduced supports such as extended reading time, pictorial instructions, or peer-assisted learning. Though not fully aligned with structured literacy principles, these behaviors represent adaptive efforts to compensate for gaps at the biological and cognitive levels. Within Frith's framework, they highlight how teachers' behavioral ingenuity can act as a compensatory mechanism in the absence of systemic scaffolding.

4. Conclusion and Implications

This study reveals that Sri Lankan primary teachers face persistent classroom-based challenges that hinder effective support for dyslexic learners. Barriers stem from conceptual misconceptions, pedagogical limitations, and systemic gaps in resources and policy (Knight, 2018; Dissanayake & Panditaratne, 2015; Peries et al., 2021). Yet the findings also highlight encouraging enablers, including teacher empathy, informal peer learning, and adaptive classroom practices (Senarath, n.d.; Indrarathne, 2019). Interpreted through Frith's causal model, the results show that deficits at the biological and cognitive levels often translate into constrained classroom behaviors, but also reveal opportunities where teacher agency can foster inclusion. To translate these findings into action, the following recommendations are presented.

Short-Term Strategies (Immediate, School-Level)

- Foster Peer-Led Knowledge Ecosystems- Encourage teacher-led learning circles, WhatsApp support groups, and micro-communities of practice to enable low-cost, high-impact collaboration (Indrarathne, 2019).
- Introduce Rapid Referral and Feedback Tools- Implement simple screening checklists and visual report cards for dyslexia indicators, co-completed by teachers and parents (Peries et al., 2021). QR-based parent portals can provide follow-up strategies and improve communication.
- Celebrate Inclusive Practices Publicly- Recognize inclusive educators through awards, social media spotlights, or school displays. Normalizing inclusive teaching through teacher and student narratives can reduce stigma (Hettiarachchi, 2021).

Medium-Term Strategies (1–3 Years, Institutional Level)

- Establish Learning Labs Within Schools- Designate "inclusive learning corners" or small-group literacy labs where teachers experiment with multisensory techniques, phonics-based instruction, and visual aids (Knight, 2018).
- Integrate Frith's Causal Model in Teacher Training- Expand in-service training workshops to include neurocognitive models, brain-based reading instruction, and early identification of dyslexia (Washburn et al., 2013; Shaywitz, 2005).

Long-Term Strategies (3–5+ Years, Policy Level)

- Reform Teacher Education Programs- Embed compulsory modules on learning disorders, structured literacy, and differentiated pedagogy into pre-service curricula at teacher training colleges and universities.
- Strengthen Policy Mandates- The Ministry of Education should formalize school-based referral systems, allocate specialist teacher posts, and incorporate inclusive education indicators into national school evaluations.
- Sustain Capacity through National Networks- Develop ministry-endorsed, province-wide teacher networks that exchange best practices and link schools with higher education institutions and NGOs.

By shifting from a reactive to a proactive stance, and by positioning teachers as empowered solution-finders rather than passive implementers, Sri Lanka and similar low-resource systems can make progress toward educational equity for dyslexic learners in primary classrooms.

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DIAGNOSING MISCONCEPTIONS IN NEWTONIAN MECHANICS USING MULTIPLE DIAGNOSTIC TOOLS AND THE CERTAINTY OF RESPONSE INDEX

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ABSTRACT

This study focuses on identifying the misconceptions related to Newtonian mechanics in Advanced Level (A/L) students, learning Physics under national curriculum for General Certificate Examination (G.C.E.) of Sri Lanka. Purposive Sample of 115 A/L students (2011-2012) representing male, female and mixed schools. This data remains still relevant as the area of Newtonian Mechanics is considerably included in current Physics Curriculum, while University selection is directly based on the results of this examination. Literature widely stated misconceptions as a belief or prior incorrect understanding, which is not scientifically correct. In this study, already established diagnostic tools: Force Concept Inventory (FCI), Mechanics Baseline Test (MBT), and Force and Motion Conceptual Evaluation (FMCE) were used. Each of the tool is accompanied by Certainty Response Index (CRI), another instrument to clarify the students' conceptual understanding as a mere guess or misconception. According to results, of three tests, incorrect answers with high certainty scores (≥3) and low average of Facility Index (FI) around 30-40%, indicated the presence of widespread misconceptions and conceptual gaps. Similarly recent findings (Rangkuti et al., 2024), has been reported low FCI scores. According to literature (Mushthofa et al., 2021) CRI has been confirm as a strong diagnostic tool. Through the integration of CRI with other diagnostic tools the interpretative power of these inventories is enhanced. Also, the statistically analyzed results using ANOVA indicated that gender difference is not effective on students' misconceptions in force and motion of tested population for MBT and FMCE except FCI. Further, this study can be used for future comparative analysis as a benchmark. In order to improve students conceptual understanding in mechanics, identifying misconceptions and replacing them and using adaptive teaching methodologies to prevent misconceptions is needed.

Keywords: *Misconceptions, Certainty of Response Index, Force Concept Inventory, Mechanics Baseline Test, Force and Motion Conceptual Evaluation*

1. Introduction

According to the findings of researches in Newtonian mechanics, is an area with deeply rooted and persisting students' misconceptions. As mentioned in various studies conducted using diagnostic tools like the FCI (Hestenes et al., 1992), MBT (Hestenes & Halloun, 1995), and FMCE (Thornton & Sokoloff, 1998) misconceptions are often resistant change through instructional methods. These tests with multiple choice questions unable to detect the difference between lack of knowledge and strongly held incorrect beliefs. Therefore, the Certainty Response Index (CRI), introduced (Hestenes et al., 1992), is used to solve this issue together with calculating the confidence level of students' responses. During this, as CRI is paired with other instruments, the power of identifying the misconceptions in mechanics among Sri Lankan Advanced Level students studying Physics is enhanced. Also, recently international research (Mushthofa et al., 2021) confirms CRI's effectiveness.

Misunderstandings related to Newtonian mechanics continue to disturb successful physics teaching and learning. According to national school curriculum of Sri Lanka, students studied Newtonian concepts under science subject from prior grades (Grade 6-11) other than Advanced Level (Grade 12-13) Physics. They initiate developing misconceptions from earlier ages, and act as barriers to develop further concepts in A/L. After years of teaching, students often hold scientifically inaccurate models that are in conflict with Newton's laws. These misunderstandings are not just knowledge gaps; they have deep roots, which makes them resistant to traditional teaching methods. Similarly, as in many other international settings, performance analysis and diagnostic evaluations consistently indicate weak conceptual understanding due to misconceptions. This research investigates the nature and strength of misconceptions in Newtonian mechanics using multiple standardized instruments along with a confidence-based metric, the Certainty of Response Index. This is highlighting the need of instructional design as the persistence levels of misconceptions students assign to them.

1.1. Objectives

- To identify dominant misconceptions related to force and motion among students.
- To assess variations in conceptual understanding across different genders.
- To evaluate the persistence levels of misconceptions that students' hold.
- To make suggestions based on diagnostic data for better conceptual understanding.

2. Methodology

The study applied descriptive, quantitative design. A purposive sample of 115 students selected representing male, female and mixed student populations from five 1AB schools studying Physics as an Advanced Level (A/L) subject under Sri Lankan curriculum and given test papers. Sinhala medium students were given translated versions of the original tests which were proof read and checked back by a well experienced Physics teacher before using.

- Force Concept Inventory (FCI): 30 MCQs on Newtonian force concepts.
- Mechanics Baseline Test (MBT): 26 MCQs emphasizing foundational understanding.

- Force and Motion Conceptual Evaluation (FMCE):43MCQs testing interpretation and reasoning.
- Certainty of Response Index (CRI): Students rated their confidence (0–5) in each answer.

Each response of multiple-choice questions separately under each of three tests (FCI, MBT and FMCE) was accompanied by a CRI rating ranging from 0 (guessing) to 5 (full confidence). Data were analyzed using descriptive statistics to calculate Facility Index (FI) and categorize misconceptions detected using FCI test according to gender. Responses with high CRI values (≥3) and incorrect answers were classified as misconceptions in relevant question.

3. Results and Discussion

The study confirms a pattern seen in international research on misconceptions in Newtonian mechanics are persistent, structurally similar across contexts, and strongly held by students. As in Figure 1, K, I, AF, AR, CI, OT, R, and G represent Kinematics, Imputes, Active Force, Action Reaction Pairs, Concatenation of Influences, Other Influences on Motion, Resistance, and Gravity respectively. Moreover, the percentages of students' misconceptions are relatively similar to the results of previous studies (Hestenes et al., 1992; Eryýlmaz, 1992; 2002).

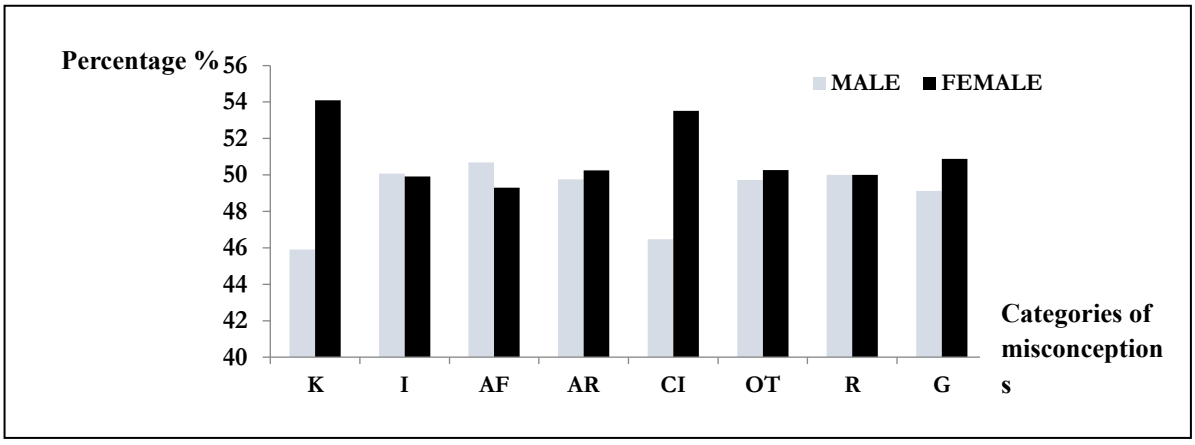

Figure 1: Percentages of students for eight categories of misconceptions in FCI
Source: Author, 2014

According to the Figure 1, percentage of misconceptions in the K and CI categories was considerably higher for female than male. This indicates that female students had high level of misconceptions in these categories. In the I and AF categories, males exhibit a higher level of misconceptions. In the Resistance category, the percentage of misconceptions among both females and males is identical at 50%.

The average Facility Index (FI) across the three tests was below 40% and 35.5%, 30.8%, and 38.9% for FCI, MBT and FMCE tests respectively as in following Table 1. This indicates that the student performance level was low under each test and high level of misconceptions.

Table 1: Summary of Test Performance and Facility Index

Test Instrument	No. of Items	Mean Score	Max Score	Facility Index (FI %)
FCI	30	10.65	30	35.5%
MBT	26	8.02	26	30.8%
FMCE	43	16.75	43	38.9%

Source: Author, 2014 (n = 115)

The integration of the Certainty of Response Index provided added depth to diagnostic analysis, enabling differentiation between confident misconceptions and uninformed guesses, indicating poor conceptual understanding. High-confidence incorrect CRI responses (Figure 2,3,4) were frequently observed, under each tool, FCI, MBT and FMCE.

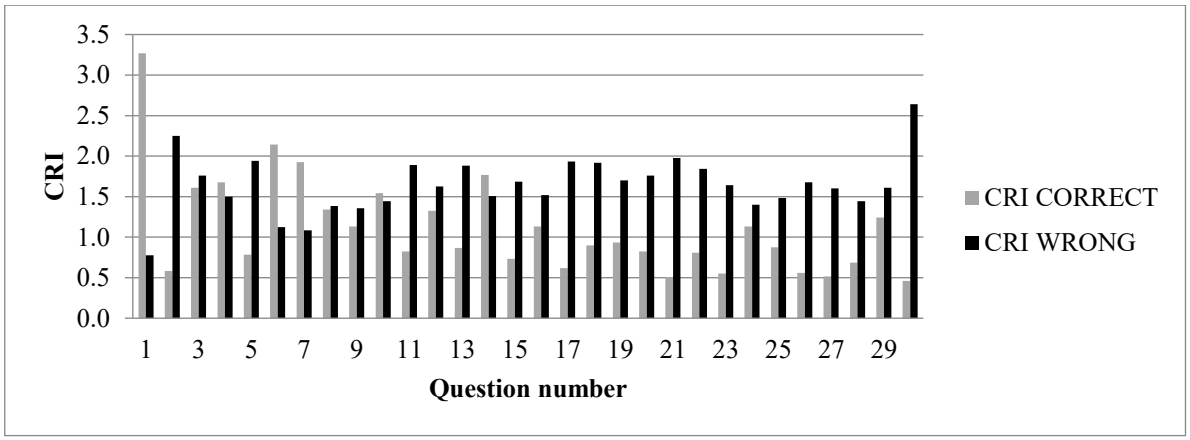

Figure 2: Average CRI for correct and wrong answers of each FCI question

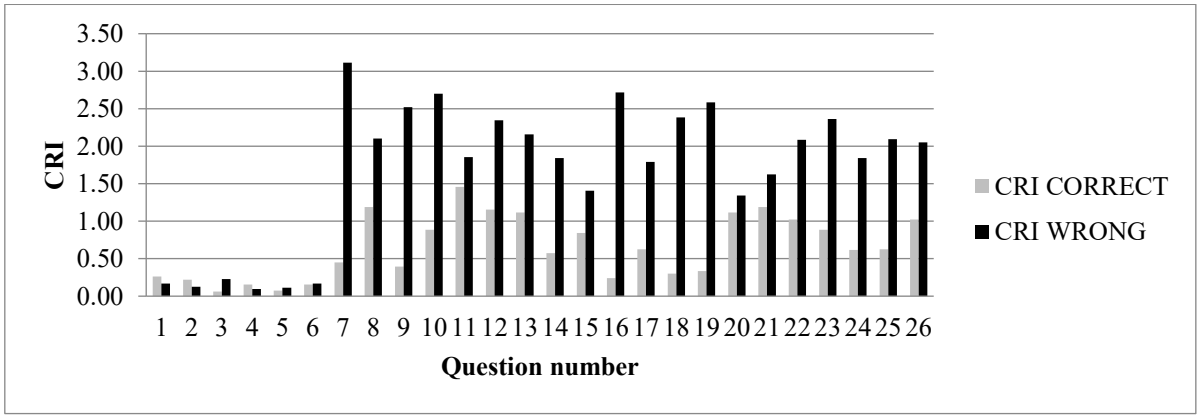

Figure 3: Average CRI for correct and wrong answers of each MBT question.

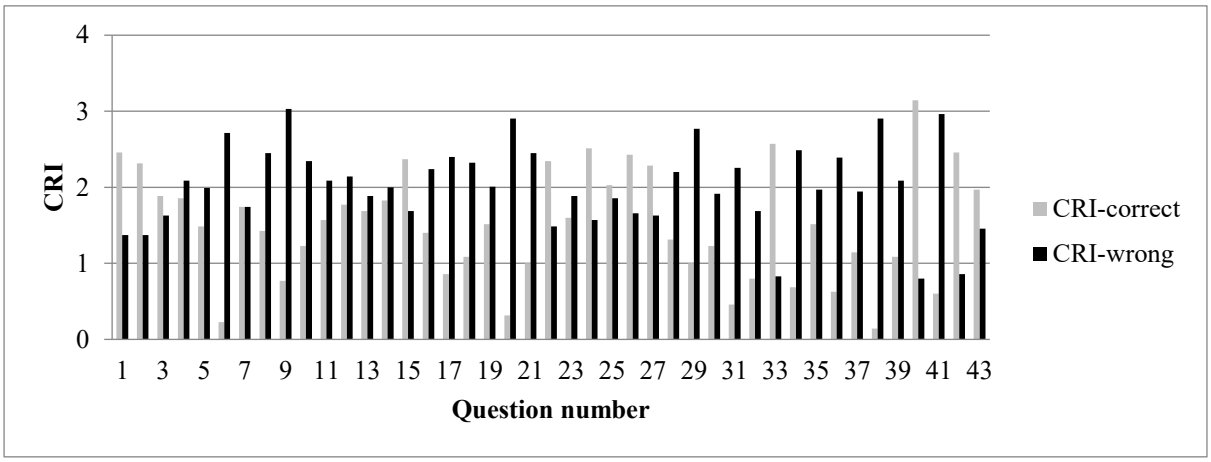

Figure 4 Average CRI for correct and wrong answers of each FMCE question

Source: Author, 2014

The misconception that continuous force is needed to sustain motion (impetus theory), Misinterpretation of action-reaction force pairs, Confusion between mass and weight. These patterns mirror findings from international CRI studies (Mushthofa et al., 2021), reinforcing the cross-cultural consistency of core misconceptions. Importantly, the CRI revealed that many students held their misconceptions with high certainty, valuable insight not obtainable through raw scores alone. This highlights the advantage of CRI-enhanced tools in conceptual diagnostics, particularly in Ordinary Level and Advanced Level education settings.

Inferential Statistics: The null hypothesis was considered for each FCI/MBT/FMCE diagnosis tests as, 'There is no significant main effect of gender on the population means of the collective dependent variables of A/L students' total test scores". Table 2 indicates the p values of each test.

Table 2 One-way ANOVA: Diagnostic Test Total versus Gender

Test	Source	DF	SS	MS	F	P
FCI	GENDER	1	138.3	138.3	5.06	0.027
MBT	GENDER	1	9.4	9.4	0.41	0.522
FMCE	GENDER	1	18.7	18.7	0.44	0.510

According to Table 2, for FCI test at λ of .95 level of significant, p=.027 indicating that we can reject this null hypothesis. That is; gender was generally effective on the students' total conceptual understanding. Whereas, for MBT and FMCE tests at λ of .95 level of significant, p=.0.522 and 0.510, indicating that we can accept this null hypothesis. That is; gender was generally not effective on the students' total conceptual understanding of force and motion through relevant test scores.

4. Conclusions

This study confirms the effectiveness of CRI when paired with FCI, MBT, and FMCE in diagnosing misconceptions in mechanics. The data demonstrate that many A/L students not only lack correct conceptual understanding but also strongly hold misconceptions that are resistant to traditional instruction. Restructuring students' misconceptions is needed for understanding of Physics concepts scientifically (Nersessian,1992). Results of this study also confirm that view. The statistical analysis reveals that, gender was generally not effective on the students' total conceptual understanding of force and motion according to MBT and FMCE test scores, but FCI scores indicates there is an effect of gender on level of misconceptions. Further, Students' mechanics achievement scores are lower than their misconception scores, that is similar with previous reports (Hestenes et al., 1992).

Despite being based on data from 2011–2012, the methodology remains highly relevant, specially as a benchmark for longitudinal studies. Future research should apply network analysis techniques to visualize misconception structures and replicate this study with current cohorts to evaluate shifts in conceptual understanding. Also, suggest replication with larger, more diverse samples.

The CRI-based diagnostic framework allows educators to distinguish between students' confident misconceptions and uninformed guessing, enabling more targeted remediation. The implications include:

- **Curricular Integration**: Emphasizing concept diagnostics in national assessments
- **Instructional Reform**: Adoption of model-based, inquiry-driven teaching
- **Teacher Development**: Focused training on conceptual change strategies and pedagogy.

The study highlights the need of using systematic, confidence-informed diagnostic tools in current science education to detect misconceptions, from prior grades before the Advanced Level to avoid barriers in students' further studies.

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A PSYCHOLOGICAL STUDY OF TENDENCY TOWARDS ACADEMIC PROCRASTINATION OF UNDERGRADUATE STUDENTS

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ABSTRACT

Academic procrastinations is a common challenge among university students in Sri Lanka. This is negatively affecting their academic performance and mental wellbeing. This study investigates the psychological factors that contributing to academic procrastination among first year undergraduates, with consideration of recent discussion and changes in education system. Employing a mixed methods approach, qualitative data were collected using semi-structured interview among 100 random university students from two separate urban and non-urban universities and among them 20 participants were selected for qualitative methods. quantitative data collected using Procrastination Assessment Scale for Students (PASS) and analysed through SPSS using Cronbach's test and T -test. PASS demonstrated that high internal reliability with Cronbach's Alpha of 0.947 (α =0.947). T-test examined the gender differences related to Procrastination and those showed males tended to procrastination less than females in Sri Lankan universities. Quantitative results indicated significant positive association with fear of failure, low self-efficacy and difficulties in regulating emotions. Qualitative analysis identified key themes such as challenges in adapting to environment, distraction from digital technology, social media, cultural pressure and academic workload. These findings highlight that procrastination is influenced by intricate interaction of emotions, cognitive, and contextual factors. The study underscores the need on intervention such as time management training, emotional support program, improve self-efficacy, improve the awareness about themselves and responsible technology use. Findings provide valuable guidance for policymakers, university administrators, educators to design strategies and reduce academic procrastination and they can promote academic wellbeing among university undergraduates.

Keywords*: Academic procrastination, First-year undergraduates, psychological factors, Self -efficacy, Fear of failure*

1.Introduction

The phenomenon of procrastination affects people in day-to-day life. The word procrastination comes from the combination of Latin words “pro” and “crastinus”. Which means put off till tomorrow. According to the American heritage dictionary (edition IV) procrastination means to put off doing something specially out of habitual carelessness or laziness. starting from industrial revolution Samuel Johnson (1751) described procrastination as “one of the general weaknesses, which, in spite of the instruction of moralists, and the remon-strances of reason, prevail to a greater or less degree in every mind.” Milgram (1992) conducted the first historical analysis of procrastination.

Academic procrastination is a prevalent issue in universities worldwide, causing students to delay tasks and negatively impact their mental wellbeing. In Sri Lanka, research on this phenomenon, particularly among first-year undergraduates, is limited. The current government is implementing changes to the academic curriculum, but without a clear understanding of the root causes, effective interventions and supportive mechanisms may be difficult to design. This study aims to fill this gap by investigating the psychological undertones of academic procrastination among Sri Lankan first-year undergraduates.

There are numerous studies have investigated the psychological background related with academic procrastination. Solomon and Rothblum (1984) found that academic procrastination is associated with two main psychological factors: fear of failure and Aversiveness of the task. Students with fear of failure were likely to suffer with factors like Low -self-esteem, anxiety, depression and irrational beliefs. They delayed their task because of emotional discomfort. According to Albert Bandura’s theory (1997) of Self – efficacy, which emphasizes that students who have lack of confidence in their academic ability are more likely to avoid academic tasks.

Several psychological theories help to explain about this phenomenon. One is Temporal Motivation Theory (TMT). It explains why students relay their task. As such it becomes a central model, that showed students tend to delay their academic task when the rewards feel far away. And, when they feel more fun or easier activities are available now. (Steel&koing,2025). Furthermore, Big Five personality traits showed that students who have low conscientiousness and high neuroticism (emotionally unstable) are more likely to have procrastination. These findings suggest that trait procrastination is mainly a reflection of low conscientious behaviour. (Shouwen burg &Lay,1995). similarly, Cognitive Behaviour Theory also linked with procrastination. Irrational beliefs, perfectionism, fear of failure and low self-efficacy play significant role in Procrastination. Researchers found that CBT based intervention can reduced this academic procrastination. (Ugwunyi,2020)

This research focuses on Sri Lankan undergraduate first-year students, addressing a gap in understanding how universities can provide better academic and psychological support to students. The study also highlights the importance of modernizing education curriculums, such as the G.C.E Advanced Level syllabus, to prepare students for higher education.

1.1 Research Objectives

The Primary objective of this research is to study the psychological factors that related with academic procrastination among first year undergraduates in Sri Lanka. Especially in the context of recent changes in education system.

And this investigation aims to:

I. To find out the prevalence of academic procrastination among first year undergraduate students
II. To understand the key psychological factors that related with procrastination.
III. To Examine how gender differences influence with procrastination.
IV. To suggest practical ways to authorities can help to overcome this academic Procrastination through curriculum design.

2. Methodology

2.1. Research design

This study structured with both quantitative and qualitative methods. This helped to gather the numerical data on academic procrastination and explored the deeper reasons behind this phenomenon.

2.2. Participants and sampling

A study involved first-year undergraduate students from two national universities, Sri Jayewardenepura and Uva Wellassa, to survey and interview them about their academic programs and cultural experiences. The participants were selected using random sampling, with 100 participants for quantitative and 20 for qualitative methods. The study aimed to capture a diverse range of experiences across different cultural settings.

2.3. Data Collection Tools

Used Mix Method for data collection.

Quantitative data was collected through, Structured psychological Questionnaires (Self-Reported survey) with 100 random sample of first year undergraduate students.

I. Demographic information
II. Procrastination and Psychological factors

Procrastination Assessment Scale -Students (PASS) -To Measures academic procrastination behaviour and reasons behind that across different academic tasks.

Qualitative Data gathered through, Conducted Semi Structured interview with a random sample of 20 participants.

2.4 Data Analysis

The study used SPSS to analyze quantitative data, including descriptive statistics, T-tests, Cronbach's, correlation analyses, and semi-structured interviews, to investigate demographics, gender differences, and psychological factors related to academic procrastination.

3. Results and Discussion

Quantitative data was analysed using correlation analysis in SPSS and It examine the relationship between academic procrastination and psychological factors. Procrastination Assessment Scale – Students (PASS) demonstrated high internal reliability with Cronbach's Alpha of 0.947 (α =0.947). That indicated that excellent internal consistency across 44 items. This result demonstrates that the instruments are well -aligned and collectively offer a dependable measure of academic procrastination. Its related psychological dimensions in the target population.

A significant proportion of participants reported frequent academic procrastination. The Correlation analysis showed that positive relationship between academic procrastination and psychological factors. It Is including fear of failure, diminished self-efficacy and challenged with emotional regulation. Among the individual items item 15 showed a notably higher mean score and T-test examined the gender differences related to Procrastination. According to that, showed males tended to procrastination less than females in Sri Lankan universities. Male tended to attribute their behaviour to boredom or lack of motivation.

Undergraduate academic procrastination is influenced by psychological, social, and environmental factors. Qualitative interviews revealed themes such as adjustment stress from transitioning to university, challenges in self-management, and distractions from technology, social media, cultural pressures, and ragging. Psychological roots included emotional and cognitive mechanisms. Quantitative findings showed that low academic self-efficacy, fear of negative judgment, and poor stress management were all associated with higher procrastination levels. Together, the results highlight that procrastination is shaped by a combination of personal, social, and contextual influences.

4. Conclusion

This study investigated the psychological tendencies towards academic procrastination among first year undergraduate students. This study combined with both qualitative and quantitative methods to get deeper understanding about this phenomenon. The finding reveals that during the adjustment stress (they shift from structured school environment to independent university environment), fear of negative judgements, emotional distress and low self-efficiency they tend towards the procrastination.

The contribution of this offers two primary contributions. First one is to understand how emotion, thoughts, environment work together to influence procrastination behaviour. Another one is to highlight the solutions for these procrastinations like time – management, self-efficiency, self-awareness, responsible technology use, training support program and improve emotional support. These findings show we need to focus on address fear of judgements, build coping mechanism and improve the wellbeing of undergraduate students.

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