

Global Perspectives on Innovation, Society and Emerging Technologies

Proceedings of 6th ICAKMPET - 2026

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Editors

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*We are honored to dedicate the proceedings of
ICAKMPET-2026 to all the participants, reviewers and
editors of ICAKMPET-2026.*

Preface

With gratification, I write this Preface to the proceedings of ICAKMPET-2026, which took place in Cebu, Philippines on January 24th and 25th, 2026. The written versions of most of the contributions delivered during the ICAKMPET-2026 conference are included in this conference proceedings book. Green Chemistry and Nanotechnology, Agriculture, Energy and Environment, Education & Teaching, Digitalization and Future Technology, Eco Science and Applied Science, Business and Management, E-Commerce & Marketing, AI and Sustainable Business Management Practices. The conference provided a fantastic opportunity for participants from all over the world to present and debate topics in their individual study areas. ICAKMPET-2026 aims to bring together the most up-to-date studies on environmental science and conservation. All approved papers were subjected to a rigorous peer-review process by two to four specialists and high-quality, relevant articles were chosen for this book.

We want to extend our heartfelt gratitude to all of the authors for their contributions to this book. We would like to express our gratitude to all of the reviewers for their constructive remarks on all of the papers, as well as the organising committee for their hard effort. Last but not least, our sincere thanks to Technoarete Publishing and their publishing team for the successful publication of the book.

Chennai, India
Philippines
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Dr. Ramesh GP
Dr. Don Vicente Carballo Real
Dr. Geraldin B. Dela Cruz

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We would like to express our gratitude to all of the faculty and non-faculty members, as well as reviewers, who contributed to the success of this conference. The ICAKMPET-2026 would like to thank all of the volunteers, conference committee members and sponsors who have given their time, energy and knowledge on a local, regional and international level.

We would also want to express our gratitude to all of the chairpersons and members of the conference committee for their unwavering support.

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About the Editors

Dr. Ramesh GP Professor of Electronics and Communication Engineering is a distinguished academician, visionary technologist and ambitious researcher with over 27 years of multifaceted experience spanning higher education, advanced research and industry leadership. His career reflects a seamless integration of academic excellence and technological innovation, positioning him as a transformative force in engineering education and applied has served as Professor and Head of Electronics and Communication Engineering at leading institutions in India and abroad. He has mentored undergraduate, postgraduate and doctoral scholars, successfully guiding 22 Ph.D. candidates. His expertise spans AI, machine learning, VLSI design and antenna technologies. With 125+ Scopus-indexed publications, an H-index of 32 and i10-index of 70, he is featured in the Stanford University-endorsed global database of top 2% cited scientists (2025). Organized Twelve International and Six National conferences publishing proceedings in Scopus. Scopus ID: 57201617809.

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Navigating Sustainable Seas: Mapping Marine Tourism Challenges to the SDGs—Blue Economy Nexus on Koh Lan, Thailand

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Abstract. This study develops a rapid, data-driven approach to detect operational sustainability gaps in island tourism by applying machine-learning sentiment analysis to user-generated TripAdvisor reviews of Koh Lan (2015–2024). A corpus of 2,388 English-language reviews was preprocessed and classified with five supervised algorithms; a Support Vector Machine (SVM) produced the best performance (accuracy 87.29%, F1 75.38%). Although the majority of reviews were positive (91.57%), a small negative subset (90 reviews, 4.25%) contained concentrated, actionable signals. Qualitative coding of negative reviews revealed five recurring problem dimensions—Scenery (37.29%), Staff and Service (29.38%), Facility (19.21%), Safety (10.73%), and Accessibility (3.39%)—yielding 179 distinct issue mentions. Each identified problem was mapped onto specific SDG targets and assessed against the Blue Economy pillars (environmental sustainability, economic resilience, and social equity), exposing persistent weaknesses in marine and waste management, infrastructure resilience, service quality, and institutional governance. The paper translates these diagnostics into a pragmatic “Blue Tourism” policy package—zero-plastic and blue-carbon initiatives, eco-infrastructure upgrades, eco-service certification, and a participatory marine governance and risk committee—to shift Koh Lan from a short-term, extractive tourism model toward regenerative stewardship. Methodologically, the study demonstrates that ML-enabled monitoring of online reviews can provide timely, high-resolution intelligence to guide sustainable destination management.

Index Terms: Marine Tourism, Sustainable Development Goals, Blue Economy, Sentiment Analysis, Machine Learning

I. INTRODUCTION

Tourism remains a critical engine of Thailand’s economy. Yet the sustained growth of mass tourism—especially in environmentally sensitive island destinations such as Koh Lan—generates significant environmental externalities and governance challenges [1, 2]. These pressures reflect a national challenge of managing destination carrying capacity and transitioning from a volume-based coastal development model to one that is more resilient and environmentally attuned [3].

Conventional sustainability assessment methods reveal a critical research gap: they typically rely on lagging indicators (such as annual waste statistics or tourist counts) or static survey instruments, thus failing to capture operational-level failures as they occur—failures that directly degrade tourist experience and local ecosystems. There is therefore an urgent need for a rapid, high-resolution tool that can identify real-time sustainability gaps in destination management—the kind of unfiltered, operationally-rooted signals that precede major failures.

To fill this methodological void, this study introduces an innovative approach using Machine Learning (ML) and Sentiment Analysis applied to extensive user-generated content (UGC) in the form of online tourist reviews. This approach yields three key benefits. First, it delivers granularity and scale: thousands of reviews can be processed automatically, offering an analytical reach beyond manual surveys and enabling real-time insight into destination performance [4]. Second, by focusing on negative sentiment as a signal, ML functions as a real-time diagnostic tool, identifying recurring service or infrastructure pain-points (e.g., overcrowded piers, inefficient ferry service, or littering) that require immediate managerial response. Third, UGC offers a less filtered and more direct reflection of tourist experience than self-reported surveys—it represents tourists’ unprompted feedback, which often reveals issues that formal survey instruments miss [5].

The operational failures—or “real-time sustainability gaps”—revealed through this analysis are then mapped onto two major policy frameworks: the Sustainable

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Development Goals (SDGs) and the Blue Economy concept. By aligning issues such as pollution and overcrowding with SDG 14 (Life Below Water) and SDG 11 (Sustainable Cities and Communities), the study quantifies the specific sustainability targets being undermined. Moreover, through the lens of the Blue Economy—which emphasizes the sustainable use of marine resources while advancing social equity and economic resilience [6]—the findings expose a systemic “Traditional Coastal Economy” failure on Koh Lan, where short-term profits trump long-term ecological health [7].

In sum, this integrated methodological framework enables the development of a regenerative policy roadmap, articulated in a “Koh Lan’s Blue Tourism Strategy”. The study’s contribution is two-fold: firstly, it offers a robust, data-driven mechanism to convert real-time tourist feedback into actionable policy intelligence; secondly, it shifts the focus from sustaining tourism to regenerating the island’s natural and social capital—guiding Koh Lan toward a resilient, regenerative model of tourism governance.

II. DATA AND METHODS

This study used an integrated mixed-methods design that combined supervised machine learning (ML), qualitative content analysis, and policy-mapping to convert unstructured UGC into quantified operational insights. The approach was designed to detect real-time sustainability gaps in Koh Lan’s tourism management and to situate those gaps within the SDG–Blue-Economy policy nexus [6], [8].

2.1 Study Area

Koh Lan (Ko Larn) is a small island located about **7.5 kilometers off the coast of Pattaya City, Chon Buri Province**, in the **eastern Gulf of Thailand**, covering an area of approximately **3.4 square kilometers**.

Renowned for its **white sandy beaches and clear waters**, the island hosts popular sites such as **Tawaen, Tien, Samae, and Nual Beaches**, attracting both domestic and international tourists. Owing to its proximity to Bangkok and easy ferry access from Pattaya, Koh Lan welcomes **over three million visitors annually**, making it one of Thailand’s busiest island destinations. However, intensive tourism has caused **environmental degradation, waste management issues, and overcrowding**, emphasizing the urgent need for **sustainable and regenerative tourism strategies**. The location of Koh Lan is shown in **Figure 1**.

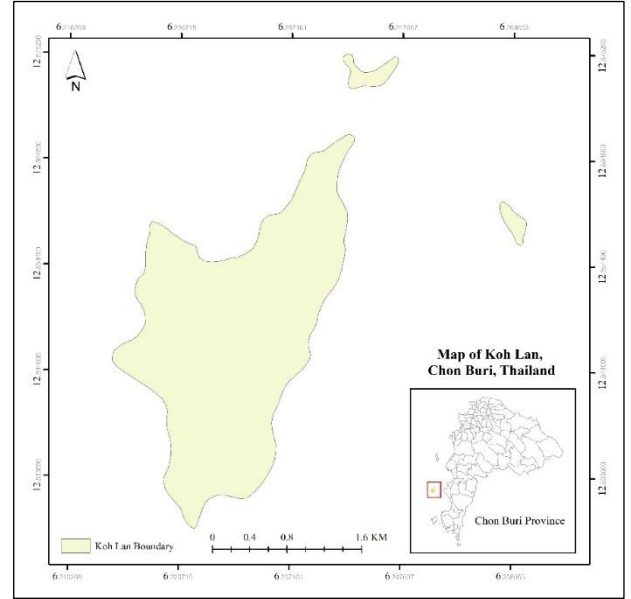


Figure 1. Location of Koh Lan, Chon Buri Province, Thailand

2.2 Sentiment Analysis

2.2.1. Data Collection and Preparation

The English-language tourist reviews were collected containing references to Koh Lan from the TripAdvisor platform covering 2015–2024 via automated web scraping implemented in Python (Selenium and BeautifulSoup). English reviews were selected to represent international tourists. Preprocessing steps included the removal of HTML tags and special characters, lowercasing, tokenization, removal of stop words, duplicate removal, and lemmatization to normalize inflected word forms prior to feature extraction [9].

2.2.2. ML-Based Sentiment Classification

The cleaned corpus was partitioned into training (80%) and testing (20%) subsets. To mitigate class imbalance, the targeted data-augmentation were used for the under-represented “Negative” class via synonym substitution and back-translation for robustness. Text features were produced using TF-IDF vectorization. Five well-established supervised algorithms were evaluated — Naïve Bayes, Logistic Regression, Random Forest, Support Vector Machine, and Decision Tree—and compared their performance using Precision, Recall, F1-score, and Accuracy [5], [10].

2.3 Negative-Issue Classification

All reviews classified as negative were exported for manual Qualitative Content Analysis (QCA) using a researcher-driven coding scheme [11]. Coders read each negative review and assigned codes using a five-category taxonomy derived from tourism service-system and coastal environmental management literature: Scenery, Facility, Staff and Service, Safety, and Accessibility. Inter-coder reliability was checked on a 10% random subsample (Cohen’s kappa > 0.80), and disagreements were resolved by consensus. This process transformed unstructured narratives into structured categorical counts that could be aggregated and compared across time.

2.4 SDGs–Blue Economy Nexus Analysis

The third phase mapped the identified operational issues onto the SDGs–Blue Economy nexus, using explicit SDG targets to specify which international sustainability commitments are being compromised. For each issue category, two analytical steps were undertaken.

2.4.1. Negative SDG Mapping

Each issue was aligned with its most relevant SDG target to clarify the precise sustainability dimension affected. Beach and marine pollution correspond to SDG 14.1 (prevent and reduce marine pollution); excessive solid waste generation maps to SDG 12.5 (reduce waste generation through prevention, recycling and reuse); urban and peri-urban environmental impacts align with SDG 11.6 (reduce cities’ environmental impact); infrastructure and transport deficits correspond to SDG 9.1 (develop quality, reliable, sustainable, and resilient infrastructure); shortcomings in tourism employment and local benefits relate to SDG 8.9 (promote sustainable tourism that creates jobs and supports local culture); and persistent governance, safety, or institutional transparency failures implicate SDG 16.6 (develop effective, accountable, transparent institutions) [6], [12].

2.4.2. Blue Economy Failure Analysis

Each issue category was then assessed against the three pillars of the Blue Economy—environmental sustainability, economic resilience, and social equity—to identify which dimensions were being undermined. This target-level mapping provides a more precise diagnostic tool than general goal-level labeling, enabling stronger policy translation and alignment with international sustainability indicators [6], [12].

2.5 Policy Recommendations Development

Diagnostic findings were translated into regenerative and integrated policy recommendations designed to be actionable for local managers and aligned with Blue Economy best practice. Priority measures included: investment in eco-infrastructure (waste treatment and pier management), zero-waste initiatives and plastic reduction, capacity building and eco-service certification for local operators, and participatory governance mechanisms to monitor and enforce environmental standards. These recommendations follow the regenerative tourism agenda that seeks restoration of social and natural capital rather than simple mitigation [13].

III. RESULTS AND DISCUSSION

3.1 Volume and Trend of Reviews

This quantitative analysis draws upon a corpus of 2,388 tourist reviews collected from the TripAdvisor platform over a ten-year period (2015–2024). Only English-language reviews were included to ensure that the sentiment analysis accurately captures the perspectives of international tourists.

An examination of the annual review volume reveals distinct temporal fluctuations in international engagement with Koh Lan. Review activity peaked in 2016 (726 reviews) and 2017 (590 reviews), corresponding with

Thailand’s pre-pandemic tourism boom when international arrivals and online engagement reached record highs [14] (Figure 2). This surge aligns with broader global trends where social media and online review platforms increasingly shaped tourist behavior and destination image [10], [15].

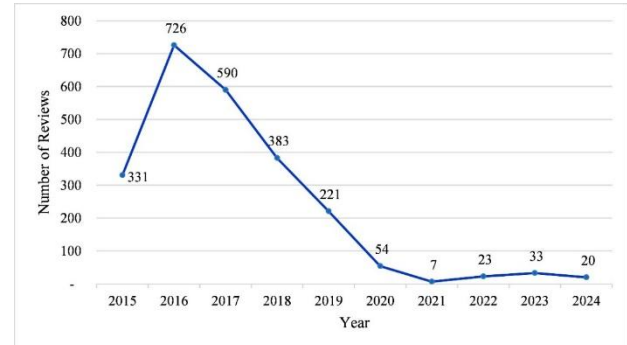


Figure 2, Annual Trend of Tourist Reviews Collected from TripAdvisor for Koh Lan (2015–2024)

A sharp decline followed after 2019, with reviews dropping to 221 in 2019 and only seven in 2021—the lowest point coinciding with international travel restrictions during the COVID-19 pandemic. Although a modest rebound appeared in 2023 (33 reviews) and 2024 (20 reviews), total volumes remain well below pre-pandemic levels. This pattern mirrors post-pandemic recovery trajectories observed across other Asian coastal destinations, where tourist flows have been slow to recover due to changing preferences, increased health awareness, and heightened sensitivity toward sustainability [16, 17].

The persistent reduction in review activity may reflect a structural shift in international travel behavior. On one hand, tourists may increasingly favor destinations perceived as sustainable, less crowded, or offering higher experiential value. On the other hand, it may indicate declining satisfaction linked to environmental degradation or over-tourism impacts [18]. Collectively, these results suggest that Koh Lan faces the dual challenge of restoring its environmental quality and re-establishing its digital presence in a global tourism market that is progressively more sustainability-conscious.

3.2 Sentiment Distribution of Tourist Reviews

Five supervised ML models—**Naïve Bayes**, **Logistic Regression**, **Random Forest**, **Support Vector Machine**, and **Decision Tree**—were trained and evaluated to classify the sentiment polarity of the collected TripAdvisor reviews. Model performance was assessed using standard metrics: accuracy, precision, recall, and F1-score.

Among the five models, the **Support Vector Machine classifier** achieved the highest overall accuracy (87.29%) and F1-score (75.38%) (Table 1), demonstrating a robust ability to handle non-linear feature spaces and distinguish subtle linguistic patterns within tourism-related text data. This result aligns with previous findings that emphasize the reliability and generalization strength of **Support Vector Machine** for sentiment analysis in tourism applications [19].

Table 1. Performance Evaluation of Machine Learning Models Used for Tourist Review Sentiment Classification for Koh Lan

Model	Accuracy	Precision	Recall	F1-Score
Naïve Bayes	85.59%	87.29%	63.28%	70.59%
Logistic Regression	85.59%	77.33%	70.01%	73.10%
Random Forest	86.02%	84.21%	62.82%	68.98%
Support Vector Machine	87.29%	87.41%	68.79%	75.38%
Decision Tree	73.30%	55.40%	60.31%	57.20%

From the total of 2,388 reviews, **2,237 (91.57%)** expressed positive sentiment, **90 (4.25%)** were negative, and **61 (4.18%)** were neutral. The peak of positive sentiment occurred during the tourism expansion years of **2016 (665 reviews)** and **2017 (546 reviews)**, paralleling the island's highest international visitation volumes. Interestingly, these same years also recorded the highest number of negative reviews (29 and 27 respectively), suggesting that environmental or service-related issues were already beginning to emerge during the height of Koh Lan's tourism boom (Table 2).

Table 2. Sentiment classification of tourist reviews for Koh Lan using the Support Vector Machine model

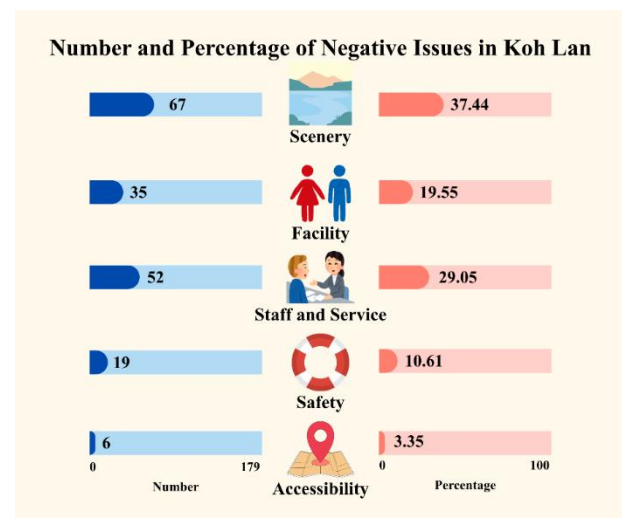
Year	Positive	Neutral	Negative
2015	326	0	5
2016	665	32	29
2017	546	17	27
2018	363	4	16
2019	211	3	7
2020	51	2	1
2021	7	0	0
2022	21	1	1
2023	31	1	1
2024	16	1	3
Total	2,237	61	90
Percentage	91.57	4.18	4.25

The overall dominance of positive sentiment underscores that Koh Lan maintains a generally favorable image among international tourists. However, even a small proportion of negative reviews provides substantial diagnostic value. As emphasized by Nawawi et al. [20], negative online comments frequently reveal operational or infrastructural deficiencies—such as overcrowding, inadequate waste management, or inconsistent service quality—that often go unnoticed in conventional survey-based assessments. Accordingly, the negative subset of reviews in this study serves as a critical input for identifying **real-time sustainability gaps** and guiding management interventions for sustainable island tourism.

3.3 Classification of Tourism Issues

The 90 negative reviews identified from the sentiment analysis were subjected to **qualitative content classification** to determine the main problem categories reported by tourists. Through systematic coding and cross-validation, five recurring issue dimensions were identified: **Scenery**, **Facility**, **Staff and Service**, **Safety**, and **Accessibility**.

Across all reviews, a total of **179 mentions** of tourism-related problems were recorded. The most frequent issue category was **Scenery (67 mentions; 37.44%)**, reflecting concerns about beach cleanliness, litter accumulation, and environmental degradation. The second most common category was **facility-related issues (52 mentions; 29.05%)**, primarily related to inadequate infrastructure, such as poorly maintained restrooms, limited waste management systems, and lack of shaded areas or seating. **Staff and Service (35 mentions; 19.55%)** referred to dissatisfaction with staff attitude, pricing, and hospitality quality. **Safety concerns (19 mentions; 10.61%)** included reckless boat operations, insufficient safety signage, and inadequate monitoring of water activities. Lastly, **Accessibility (6 mentions; 3.35%)** encompassed inefficient ferry scheduling, overcrowded piers, and poor local transport connectivity (Figure 3).

**Figure 3.** Number and percentage of negative issue mentions in Koh Lan tourist reviews

The dominance of **environmental and service-related issues** corroborates existing research, which emphasizes that tourist satisfaction in island tourism heavily depends on **environmental quality** and **service reliability** [21]. The findings suggest that Koh Lan's rapid tourism expansion during its peak years was not matched by corresponding investment in **environmental protection**, **infrastructure resilience**, or **institutional governance**. This imbalance typifies a **Traditional Coastal Economy** model, wherein short-term revenue generation often supersedes the long-term imperative of ecological and community sustainability [6].

The concentration of complaints regarding scenery and service quality thus signals the urgent need for a **regenerative management approach**, integrating sustainable infrastructure upgrades, community-based service training, and stricter environmental regulations to prevent further deterioration of the island's natural assets.

3.4 Policy Implications: Toward a Blue Tourism Strategy for Koh Lan

Building on the analysis of negative reviews, this study formulates targeted **policy recommendations** framed within the **SDGs–Blue Economy nexus**. The objective is to guide Koh Lan's transformation from a traditional,

resource-intensive tourism model toward a **regenerative blue tourism strategy** that enhances ocean health, social equity, and economic resilience (Table 3).

3.4.1 Restoring marine natural capital (Scenery)

Degradation of beaches and nearshore waters directly undermines SDG 14.1 (prevent and reduce marine pollution) and SDG 12.5 (reduce waste generation through prevention, recycling and reuse). Koh Lan should implement an integrated Zero-Plastic and Blue-Carbon Initiative that enforces single-use plastic bans, scales island-wide waste reduction and recycling, upgrades wastewater treatment to prevent marine discharge, and advances blue-carbon restoration (mangrove/seagrass) where feasible [12], [22].

3.4.2 Upgrading blue infrastructure and mobility (Facility, Accessibility)

Facility and accessibility failures implicate SDG 9.1 (develop quality, reliable, sustainable, and resilient

infrastructure) and SDG 11.6 (reduce cities' environmental impact). Priorities include investment in eco-piers and renewable-powered public facilities, improved pier scheduling and crowd management, and introduction of low-emission shuttle services and active-mobility options to reduce congestion and per-capita emissions.

3.4.3 Strengthening human capital and governance (Staff and Service, Safety)

Service quality and safety shortfalls implicate SDG 8.9 (promote sustainable tourism) and SDG 16.6 (develop effective, accountable, transparent institutions). Recommended actions are an Eco-Service Certification program combining hospitality training with marine stewardship, and the establishment of a Marine Governance and Risk Committee (government, operators, community) to co-manage safety, enforce maritime rules, designate protected/swim zones, and publish transparent monitoring data [13].

Table 3. Policy Framework for Koh Lan's Blue Tourism Strategy

Strategic Pillar	Associated Issues	Relevant SDG target(s) and Blue Economy Component	Koh Lan Blue Tourism Strategy
Addressing environmental failure	Scenery	Environmental sustainability; SDG 14.1 (prevent and reduce marine pollution); SDG 12.5 (reduce waste generation through prevention, recycling and reuse)	Green/Blue infrastructure: advanced wastewater treatment, island-wide waste reduction and recycling, eliminate single-use plastics, beach clean-ups and blue carbon restoration.
Addressing infrastructure and mobility	Facility, Accessibility	Infrastructure and resilience; SDG 9.1 (develop quality, reliable, sustainable, and resilient infrastructure); SDG 11.6 (reduce cities' environmental impact)	Eco-infrastructure and low-emission mobility: eco-piers, renewable-powered public facilities, improved pier management, scheduled low-emission shuttle services, pedestrian and bicycle circulation.
Addressing social equity and governance	Staff and Service, Safety	Social equity and institutions; SDG 8.9 (promote sustainable tourism); SDG 16.6 (develop effective, accountable, transparent institutions)	Human capacity and co-management: Eco-Service Certification and livelihood programs; Marine Governance and Risk Committee for co-management, safety enforcement, and transparent monitoring.

IV. CONCLUSION

This study applied machine learning-based sentiment analysis to 2,388 English-language TripAdvisor reviews of Koh Lan (2015–2024) to assess international tourists' perceptions and identify sustainability gaps. While the island generally maintains a positive image, significant environmental and service-related issues persist. Review activity peaked in 2016–2017 but declined sharply after 2019, reflecting the combined effects of the COVID-19 pandemic and a global shift toward more sustainable travel preferences. Despite representing only 4.25% of total feedback, negative reviews revealed critical weaknesses in scenery, facilities, staff and service, safety, and accessibility—issues that directly impede key SDG targets, including **SDGs 8.9, 9.1, 11.6, 12.5, 14.1, and 16.6**. Collectively, these findings indicate that Koh Lan's tourism model remains anchored in a short-term *Traditional Coastal Economy* paradigm rather than advancing toward a regenerative *Blue Economy*

framework that aligns with global sustainability objectives.

Methodologically, the study demonstrates the reliability of machine learning—particularly the Support Vector Machine model—as an effective real-time diagnostic tool for sustainability assessment. By transforming unstructured user feedback into actionable intelligence, the approach bridges the gap between tourist perceptions and management responses, aligning with contemporary trends in data-driven destination monitoring.

The main limitation of this research lies in its reliance on English-language reviews, which may overlook perspectives from domestic or regional tourists. Future studies should incorporate multilingual datasets and advanced deep-learning models such as BERT to enhance contextual accuracy and cross-cultural interpretation.

Practically, the study advocates for a Blue Tourism Strategy emphasizing regenerative actions: implementing zero-plastic and blue carbon initiatives, upgrading eco-

infrastructure and transport systems, introducing Eco-Service Certification programs, and establishing a Marine Governance and Risk Committee. These measures can strengthen environmental stewardship, empower local communities, and enhance Koh Lan's global competitiveness as a sustainable island destination.

Overall, this research confirms that machine learning–driven sentiment analysis offers a powerful tool for identifying real-time sustainability challenges. Integrating digital analytics with the SDG–Blue Economy nexus can help Koh Lan transition from sustaining growth toward regenerating natural and social capital, ensuring long-term resilience and inclusive prosperity.

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Amidst the Demagogues: An Appraisal on BASC Students' Views in Studying Philippine History in the “Age of Disinformation”

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Abstract. This study investigated the views of Bulacan Agricultural State College (BASC) students regarding their study of Philippine History in the “Age of Disinformation” in the aspect of cognitive-historical, digital literacy and pedagogical factors. A qualitative research design was employed through semi-structured interview to gather in-depth insights of the participants. The researcher utilized a validated researcher-made list of interview questions for the thirteen (13) student-participants who had taken the course HIST100 (Readings in Philippine History) from their previous semester. Thematic analysis was employed by the researcher towards its findings that revealed the cognitive-historical features that influence students in learning Philippine History are professors’ proficiency, credibility of online resources, presence of social media, lack of reliable resources, and the educational system. The study identified also that in evaluating the credibility and reliability of the historical information, the students have digital literacy skills in looking at the source of information, looking at the author’s reputation and credibility, and cross referencing/fact-checking. Another generalization justified that faculty members who teach Philippine History provide credible and reliable historical evidence, correct false historical information, and are pedagogically competent in addressing the challenges of disinformation. Furthermore, the researcher recommends that Higher Education Institutions (HEIs) should strengthen their partnerships with historical organizations to build academic linkages, history professors should consider authentic assessments and real-life teaching methods in teaching Philippine History, and HEIs should be actively engaged in conferences that may allow both their professors and students to meet experts in the field of history, and to hear about latest researches and trends.

Index Terms: Philippine History, Age of Disinformation, Cognitive-historical factors, Digital Literacy, Pedagogy in History

I. INTRODUCTION

In today’s digital era in the Philippines, where the line between truth and misinformation is increasingly difficult to distinguish, the study of Philippine History has become both more important and more challenging. Filipino students are now confronted with an overwhelming flow of information—some reliable, some misleading, and others entirely false. This complex situation is especially evident in learning Philippine History, where historical accounts are often closely linked to social identity, cultural context, and shared memory.

The Philippines, known for its diverse and multifaceted history, provides a meaningful context for this kind of investigation. As Filipino students engage in studying their nation’s past, they encounter not only the complexity of historical developments but also the growing problem of disinformation. The so-called “Age of Disinformation” refers to a period marked by the rapid spread of inaccurate or deceptive information, largely driven by digital technologies and reinforced by social media platforms that influence various areas, including historical narratives and events (McMurtrie, 2021). In this environment, the credibility of historical accounts is often challenged, allowing alternative interpretations and even conspiracy

theories to circulate alongside verified facts (McPherson, 2023).

Negative historical revisionism, as a manifestation of disinformation, has been widely used by demagogues to shape public opinion and strengthen their authority by manipulating historical narratives for personal or political gain (McMurtrie, 2021). These individuals, particularly politicians, may distort or selectively highlight past events to justify their perspectives and ideologies. Addressing this issue requires societies to remain critical, uphold historical integrity, and encourage analytical thinking among citizens (Wineburg & McGrew, 2017). In the Philippine context, some scholars identify the victory of former president Rodrigo Roa Duterte in the 2016 Presidential Elections as a turning point in the rise of disinformation, noting that his campaign heavily utilized social media and marked a period characterized by intensified attacks on journalists, independent media, and news organizations (Simpeng, 2020).

Moreover, demagogues who employ historical revisionism often do so to legitimize their authority and ideologies as they create a narrative that aligns with their present-day political or social goals. In consonance, manipulation of historical facts not only distorts the collective memory of a society but can also be used to

justify actions that may have been condemned under accurate historical interpretation (Brookins, 2021). The same on what happened on the presidency of former president Duterte when Facebook, Twitter and YouTube became the havens of internet trolls and fake news peddlers who pioneered the rampant historical negationism and reputation rehabilitation on the presidency of former president Ferdinand Marcos Sr. (Pomerantsev, 2020).

Students studying Philippine history today encounter significant challenges. They must distinguish between accurate and misleading information, gain a deeper understanding of their cultural heritage, and develop critical thinking skills necessary for responsible citizenship. In the current environment of widespread online misinformation, the presence of fabricated historical claims, conflicting interpretations, and conspiracy theories makes the study of history more complex (Domingo, 2021). Supporting this, research on students' perspectives in the "Age of Disinformation" indicates that young people are frequently exposed to diverse digital sources, many of which contain bias, inaccuracies, or even entirely fabricated content (Alterman, 2019). These exposures can significantly influence how students perceive society, including their interpretation of historical events.

This study aimed to examine the diverse perceptions that students bring to the study of Philippine History within the context of disinformation. It seeks to understand how students interpret the historical information they encounter, how they cope with the challenges brought about by misinformation, and how these perceptions shape their learning experiences. Additionally, the research explores the emotional and psychological reactions of students when faced with unclear or contested historical narratives. By closely analyzing students' perspectives, the study intends not only to contribute to ongoing discussions in history education but also to provide insights for developing teaching strategies and approaches that can help students become more critical and discerning consumers of historical information in the digital era. Given the growing complexity of studying history in the "Age of Disinformation," this issue remains highly relevant for educators, historians, and society, and this research aims to present a thorough understanding of this important concern.

In the backdrop of the "Age of Disinformation" caused by demagogues, this study aims to investigate the views of Bulacan Agricultural State College (BASC) students regarding their study of Philippine History in the aspect of cognitive-historical, digital literacy and pedagogical factors. Given the proliferation of disinformation in the digital age, this study specifically sought to address the following:

1. To determine cognitive-historical features that influence students' learning experiences in encountering disinformation while studying Philippine History in the "Age of Disinformation";
2. To describe the digital literacy skills of students in evaluating the credibility and reliability of the

historical information they encounter while studying Philippine History in the face of disinformation; and

3. To describe ways how faculty members address the challenges of disinformation in teaching of Philippine History.

II. METHODOLOGY

Research Design

The researcher employed a qualitative type of research that involves collecting and analyzing non-numerical data (e.g., text, video, or audio) to understand concepts, opinions, or experiences by means of an interview technique. It was described also by Bhandari (2020) as a research technique that can be used to gather in-depth insights into a problem or generate new ideas for research.

In the case of this study, a qualitative type of research is suitable because the researcher wants to investigate the views of students regarding their study of Philippine History despite being in the "Age of Disinformation". As inclusivity for this study, the researcher covered the views of the participants in the context of Philippine History as a whole not merely focusing on a single period.

Characteristically, the researcher used the qualitative approach of "Narrative Research" in this study. In fact, the core of this study wants to examine how stories are told to understand how student participants perceive and make sense of their experiences in studying Philippine History.

Sources and Materials

Regarding the implementation of the qualitative data gathering, the researcher utilized a researcher-made list of interview questions that were aligned with the questions relevant to the qualitative part. To ensure the validity of the interview guide questions, the researcher sought the expertise of Social Science research experts (and curriculum developers of History curriculum in higher education) to validate the interview questions as Third-party Validation.

The responses of the participants from these questions were transcribed and thematized (some situations happened that the researcher translated the questions into Filipino language because of the students' preference).

Data Collection Techniques

Prior to the conduct of the study, the researcher took a permission from the President of Bulacan Agricultural State College (BASC) and upon receiving the permit of approval, the researcher coordinated with the Deans of different institutes for the schedule of the interview as qualitative data gathering including the program chairs of their institutes who may be the coordinating persons in regards to the conduct of the interview. Following this process, the researcher coordinated also to the program chairs in order to identify the students who are the ideal participants of the data gathering procedure.

Likewise, the researcher conducted the study as pursuant to the guidelines prescribed by the Republic Act No. 10172 or the "Data Privacy Act of 2012" (To protect the fundamental human right to privacy of communication while ensuring free flow of information to promote

innovation and growth and the State's inherent obligation to ensure that personal information in information and communications system in government and in the private sector are secured and protected). In connection, the researcher formulated a written-consent to the chosen participants as part of the protocols before starting an interview (Padget, 2017).

After identifying the respondents from each college/institute, the researcher provided instructions to student-participants regarding the schedule and guidelines for the data gathering process that encompasses the qualitative data collection. Furthermore, during the actual interview, the researcher personally asked the interview guide questions to each respondent.

Further, the proponent conducted the actual data gathering by means of semi-structured interview in fact that the proponent developed and used "interview guide" or a list of questions and topics that need to be covered during the conversation, usually in a particular order (Cohen & Crabtree, 2016). Consequently, the researcher conducted the actual data gathering by means of a semi-structured interview.

Besides, after writing the results and discussions of this study, the researcher employed a Respondent Validation that involves sharing the preliminary findings with the participants to verify whether the interpretations and conclusions accurately reflect their perspectives and experiences (Birt et al., 2016). During this process, the respondents were invited to review the summaries of their inputs and provide feedback, ensuring that their ideas were accurately represented in the analysis. This crucial step helped refine the findings and contributed to the overall trustworthiness of the results.

Sampling Procedure

Researcher applied purposive sampling in determining the student participants for the study and the number of students intended to be part of the interview. In relation to, this sampling technique which is a sampling method that manipulate the intentional selection of participants based on their capacity to give essential idea that is needed on the research proper (Robinson, 2014). Correspondingly, this sampling method also used in identification of information-rich cases related to the phenomenon of interest as research subjects rather than starting with a predetermined sampling frame (Palinkas & Horwitz, 2015).

In relying to this sampling procedure, the researcher purposely selected the participants by having an inclusion criteria: (a) bona fide- regular students of BASC and (b) students who had taken HIST100 (Readings in Philippine History) from the previous semesters (starting Second semester AY 2023-2024 backwards) or currently enrolled on the current semester (First semester, AY 2024-2025).

For the sample size of the participants, the researcher interviewed one student in each program offered by BASC Main campus in Pinaod, San Ildefonso, Bulacan (Doctor of Veterinary Medicine, Bachelor of Science in Agriculture, Bachelor of Elementary Education, Bachelor of Secondary Education, Bachelor of Science in Development Communication, Bachelor of Hospitality

Management, Bachelor of Science in AgriBusiness, Bachelor of Science in Business Administration, Bachelor of Science Food Technology, Bachelor of Science in Geodetic Engineering, Bachelor of Science in Agriculture and Biosystems Engineering and Bachelor of Science in Information Technology) and BASC Doña Remedios Trinidad Campus in Sapang Bulak, Doña Remedios Trinidad, Bulacan (Bachelor of Science in Agroforestry). The Program chairs of the institutes were the one who selected one (1) student to participate in the qualitative data gathering. Furthermore, the study had a total of 13 participants.

Data Analysis Scheme

Thematic analysis was employed by the researcher to analyze the responses of the participants as it is an analytic procedure of examining qualitative data by identifying, analyzing, and reporting recurring patterns within a dataset (Kiger & Varpio, 2020). Specifically, the researcher followed the steps/phases in having this method of qualitative analysis as stated by Eldh, Arestedt and Bertero (2020).

III. FINDINGS AND DISCUSSION

Cognitive-historical features that influence students' learning experiences in encountering disinformation while studying Philippine History in the "Age of Disinformation"

From the interview guide questions regarding the cognitive-historical features that influence students' learning experiences in encountering disinformation while they are studying Philippine History in the "Age of Disinformation, the findings were presented in the following paragraphs.

To investigate the views of the students in studying Philippine History in the "Age of Disinformation," they were asked about the cognitive-historical features that influence their learning experiences in encountering disinformation. Some sort of their answers are presented in Table 2:

Table 2. Participants' views on Cognitive-historical features that influences their learning of Philippine History amidst the "Age of Disinformation"

Participant	Responses
Participant 2	<i>"I was able to understand historical narratives and other controversies about the past since our instructor is excellent and explains everything in detail so that we fully get what we are learning."</i>
Participant 4	<i>"Hearsay or unverified information from internet sources are often considered the most drastic game changers in terms of information, and even the slightest passing of the message can alter the real information about a certain vital topic."</i>

Participant 5	<i>“Social media is a key factor as students can easily garner misinformation in different sites that are not legitimate to use. This is alarming especially now since most students are raised in a social media centric environment.”</i>
Participant 7	<i>“Books and social media also play a huge role. With so much fake news around, it's hard to know what's true. This has made me more careful about what I believe and pushed me to double-check facts for myself. That is why we are also facing a scarcity of reliable sources.”</i>
Participant 8	<i>“In this digital age, students have shorter attention spans and prefer simplified information. Therefore, creating easily understandable and accessible content is crucial to reduce the risk of falling victim to disinformation disguised in lengthy and thorough formats.”</i>

In relying with the responses of the student-participants, five (5) themes had emerged, (1) professors' proficiency, (2) credibility of online resources, (3) presence of social media, (4) lack of reliable resources, and (5) the educational system. Furthermore, these students affirmatively agreed that these factors influence their academic journey in studying Philippine History regardless of topics. They also added that these factors may have positive and negative sides as they affect students' learning of the mentioned course especially in a time where spreading of false information about the past is prominent.

A deeper examination of the participants' responses revealed that these factors may hinder students' learning of Philippine History when they manifest negatively. In terms of instructional competence, most participants emphasized that the “teacher factor” plays a crucial role, as educators are responsible for applying historiographical approaches, explaining inconsistencies across historical periods and sources, and shaping an appropriate learning environment in the classroom. The reliability of online sources also emerged as a major concern, with participants noting that many websites can be easily modified and may present misleading information as factual, often influenced by deliberate rebranding efforts that promote distorted or negationist narratives.

In line with this, participants also highlighted the impact of social media and the lack of trustworthy resources, observing that students tend to rely on quick and readily available information from various online platforms. As members of the millennial generation, these students are particularly vulnerable to disinformation due to their frequent exposure to digital media, which are commonly used channels for spreading inaccurate content. Furthermore, the participants identified the Philippine educational system as another influential factor, noting that the content, competencies, and performance standards in teaching Philippine History are largely guided by

curricula and policies from the Department of Education (DepEd) for basic education and the Commission on Higher Education (CHED) for tertiary level. These findings are supported by existing studies that emphasize the role of cognitive and historical factors in shaping students' learning experiences amid disinformation in the “Age of Disinformation.”

On professors' proficiency, those who are well-trained and passionate in teaching Philippine History can engage students more effectively, fostering a deeper appreciation of the past (Alcantara, 2023). Conversely, the lack of training and professional development opportunities for professors often results in a superficial treatment of historical content, limiting students' ability to critically analyze historical events and narratives (David, 2024).

Moreover, scarcity of primary sources and the presence of biased colonial accounts threatened the development of an accurate historical record (Constantino, 2018). Consequently, professors and students must rely on secondary sources that may perpetuate inaccuracies, thereby affecting the authenticity and depth of historical understanding (Agoncillo, 2018).

In addition, the presence of social media amplifies the dissemination of false historical narratives, which are often perpetuated by unverified sources and individuals as “demagogues” with specific political agendas (Tuazon, 2020). This misinformation is further compounded by the non-academic designs of social media, which prioritizes engagement than accuracy, leading to the viral spread of misleading content (Soriano & Cruz, 2021). Through this, the historical consciousness of the Filipinos is increasingly shaped by distorted accounts, undermining educational efforts and fostering wrong interpretations of the nation's past (Chua, 2019).

Nevertheless, in the aspect of educational system, the concern on the removal of Philippine History in high school was placed at the disadvantage point especially in this time of the “Age of Disinformation” in the Philippines. Despite having a separate course in the tertiary level, the removal of history as a discipline of study in younger years of Filipino youth may become a beginning to be less essential and could further in effect result in denigration of students' critical thinking (LaFrance, 2020).

Digital literacy skills of students in evaluating the credibility and reliability of the historical information while studying Philippine History in the face of disinformation

The succeeding paragraphs present the findings of the semi-structured interviews conducted to gather the digital literacy skills of students in evaluating the credibility and reliability of the historical information while studying Philippine History in the face of disinformation.

Moreover, the researcher also wanted to determine the views of the students on their literacy skills in evaluating the credibility and reliability of the historical information while studying Philippine History in the face of disinformation. Gist of their answers is presented on Table 3:

Table 3. Participants' views on their digital literacy skills in evaluating the credibility and reliability of the historical information in learning of Philippine History in the face of disinformation

Participant	Responses
Participant 1	<i>"Evaluating information has influenced my understanding of the historical events in a way that I started to be a critical observer of the information given about history. I learned that not all information posted on the internet is correct and enough for me to trust easily, so becoming a critical viewer or reader is important."</i>
Participant 4	<i>"I also verify the information by double checking if that information is consistent with other sources. I also check documentaries and interviews from YouTube because in that way, I can make sure that the information is true."</i>
Participant 10	<i>"I check the credentials of the authors or sources, particularly when reading content or viewing media related to history. I trust information shared by legitimate historians online and documentaries produced by journalists, often featuring respected historians, as credible sources."</i>

From the participants' answers during the interview, there are three (3) themes had appeared: (1) looking at the source of information, (2) looking at the author's reputation and credibility, and (3) cross referencing/fact-checking. These shared ideas of the participants proved that despite the presence of the "demagogues" that have drastically caused the spread of false knowledge in the "Age of Disinformation," they are equipped by digital literacy skills that are essential in evaluating the credibility and reliability of the historical information.

Further analysis of the participants' responses revealed that although students are exposed to misinformation from various online sources, they actively engage in strategies to verify historical accuracy. Many participants highlighted the importance of evaluating sources by reviewing the references and cited works in books or articles to determine whether the information is based on credible scholarly research or unreliable databases. The credibility of the author also emerged as a significant factor, as students tend to trust works written by recognized historians, particularly those with advanced academic qualifications and affiliations with reputable institutions. In addition, participants identified cross-referencing and fact-checking as essential skills in validating historical claims, as these involve comparing information with primary sources and other reliable materials to confirm or challenge a narrative. These findings align with existing studies that emphasize the importance of students' digital literacy skills in addressing disinformation while studying Philippine History in the "Age of Disinformation."

In evaluating the credibility and reliability of historical information in Philippine History, it is important to

examine the sources of information as many history experts emphasize that primary sources offer a more direct glimpse into historical events and are less bias (Domingo, 2021). It may be furtherly understand that in the era of modern technological advancements, social media platforms primarily created to enhance human connectivity and boost the information sharing, but unfortunately, these are vulnerable and can lead to online information manipulation by the demagogues. By critically assessing the origins and context of these historical sources, students can better discern the authenticity and reliability of historical accounts, thus contributing to a more comprehensive understanding of Philippine History on a larger scale (Sinpeng & Arugay, 2020). This concern was proven by the investigation conducted by Rappler in 2019 where they uncovered a web of networked propagandas from various internet sites that exaggerating Marcos Sr.'s achievements, denying the human rights violations during the 1972-1981 Martial Law and critiquing rivals and mainstream media (Mendoza, 2020).

On the other hand, the credibility of an author significantly influences the trustworthiness of their interpretations and conclusions especially in historical narratives in fact that renowned historians such as Teodoro Agoncillo and Renato Constantino are recognized for their scholarly contributions and have shaped much of the contemporary understanding of Philippine History (Arugay & Baquisal, 2022).

Additionally, an author's background, including their academic qualifications, affiliations, and previous works, provides context to their perspectives and potential biases (Posetti & Matthews, 2018). By critically assessing an author's reputation and credibility, researchers can better gauge the reliability of historical narratives and ensure a more accurate and balanced interpretation of Philippine History (Trinidad, 2023).

Further, as cross-referencing involves comparing multiple sources to identify consistencies and discrepancies, it was proved that it helps information validation by checking them against different accounts and evidence (Mendoza et al., 2023). This method lessens the biases inherent in individual sources, ensuring a more comprehensive and accurate understanding of historical events (Pandan et al., 2023). For instance, in studying Philippine History, cross-referencing records, Filipino revolutionary documents, and foreign observers' accounts provides a balanced view that no single source could offer (Balod & Hameleers, 2021). By systematically deciphering information from diverse sources, students can construct a more reliable and nuanced narrative, thus enhancing the overall integrity of the historical atmosphere in the context of Philippine History (Acevedo, 2020).

Faculty members' strategies in addressing the challenges of disinformation in teaching of Philippine History

After the qualitative data gathering, the findings pertaining to how students observe their professors' strategies in addressing the challenges of disinformation

in teaching of Philippine History are presented in the next paragraphs.

To identify the faculty members' strategies in addressing the challenges of disinformation in teaching of Philippine History, the student-participants were asked about their professors' strategies in addressing the challenges of disinformation in teaching of Philippine History. Sample of their answers are can be gleaned from the Table 4:

Table 4. Participants' views on faculty members' strategies in addressing the challenges of disinformation in teaching Philippine History

Participant	Responses
Participant 7	<i>"My History professor usually presents authentic pictures to class and tells anecdotes and stories from credible sources. Sometimes he gives us assignments about past events and instructs us to go to the library for research since not all information on the internet is reliable."</i>
Participant 11	<i>"I observed one of my professors, he emphasizes the importance of promptly correcting any misinformation shared by students about the Philippines' past. Professors must respond with accurate information in a respectful manner, emphasizing the need to be adaptable and open to learning, unlearning, and relearning information in the current century."</i>
Participant 13	<i>"Our History professor made sure that he is able to clear things up including our misconceptions. He also did not just spoonfed us with information. He also made sure that we are self-directed."</i>

Three themes were identified from the responses for this part of the interview: (1) providing credible and reliable historical evidence, (2) correcting of false historical information, and (3) pedagogical competence of the professors. Upon the observation of the students by their professors, these strategies emerged as the most prominent in addressing the nation-wide concern on disinformation in teaching Philippine History.

Deeper analysis on these findings gleaned that student-participants are observant of their professor's teaching strategies in combating disinformation since not all these ways of educating students are applicable in all aspects. All of the participants mentioned that their professors prioritize the use of primary sources because they provide more credible and reliable historical evidence (e.g., pictures, documents, newspapers) rather than relying on secondary sources (e.g., textbooks, work texts). The participants also appreciate the manner on how their professors correct false historical information that they know before, aside from they feel great and mind-blowing if they discover what is the truth behind a specific part of history, they may now have the chance also to accurately analyze what really happened before. Otherwise, the

pedagogical competency of the professors was also pointed-out during the interview where the participants specifically mentioned that their professors had their *"Mastery in Pedagogy"* as they usually use techniques that cultivate critical thinking skills of the students not only focusing on memorization process. Engaging students to Information, Media, and Technology activities, collaborative activities that encourage informative discussions, urging students to know something by means of interview method, exposing students to original documents regarding Philippine History are some of their professors' pedagogy that they shared during the interview. In the same way, these findings were aligned with several studies indicating effective teaching strategies in addressing the challenges of disinformation in teaching Philippine History. Parts of their results can be read on the succeeding paragraphs.

In the context of teaching Philippine History, it is a must for professors to provide credible and reliable historical evidence to counteract the pervasive spread of misinformation because the accuracy of historical knowledge is crucial for fostering critical thinking and informed citizenship among students (Balod & Hameleers, 2021). Providing well-researched and authenticated historical evidence helps students develop the skills to discern factual information from wrong ones, a necessity in an age where misinformation is rampant, particularly on social media (Alic & Bual, 2021). Furthermore, accurate historical education promotes a deeper understanding of national identity and heritage as it empowers students to critically engage with historical narratives (Garcia, 2020). Professors as educators and researchers, therefore, play a pivotal role in preserving the integrity of Philippine History by ensuring that their instructional materials are grounded in reliable sources, thus safeguarding the intellectual and cultural development of their students (Carson & Fallon, 2021).

Correspondingly, correcting false historical information is crucial to ensure the accuracy and integrity of students' understanding of their national heritage because misconceptions and inaccuracies in historical knowledge can lead to distorted views of the past, which can formulate biases and hinder critical thinking skills (Acevedo, 2020). Through this, educators have the responsibility to present historical facts accurately to students who should be capable of making sound judgments about current and future societal issues. Correcting false information also helps to combat the spread of historical myths and misinformation, which can have harmful social and political implications (Alic & Bual, 2021). By addressing and rectifying inaccuracies, professors not only preserve the authenticity of historical narratives but also promote a culture of intellectual honesty and critical inquiry among students (Alcantara, 2023).

On the aspect of professors' pedagogical competence, strategies and techniques in teaching Philippine History directly influences the quality and depth of students' historical understanding as history professors must possess both subject matter knowledge and pedagogical skills to effectively convey complex historical concepts

(Bautista, 2021). Competent professors are better equipped to engage students in critical thinking, encourage the analysis of multiple perspectives, and foster a nuanced understanding of historical events (David, 2024). Furthermore, professional competency in history education ensures that teachers can adapt to new research and incorporate updated historical narratives into their teaching, thereby keeping the curriculum relevant and evidence-based (Pandan et al., 2023).

IV. GENERALIZATIONS AND RECOMMENDATIONS

Based on the investigation into students' views in studying Philippine History in the "Age of Disinformation" at Bulacan Agricultural State College, the researcher drawn the generalization that the cognitive-historical features that influence students in learning the course are professors' proficiency, credibility of online resources, presence of social media, lack of reliable resources, and the educational system. Further generalization indicated that in evaluating the credibility and reliability of the historical information, the students have digital literacy skills in looking at the source of information, looking at the author's reputation and credibility, and cross referencing/fact-checking. Another generalization justified that faculty members who teach Philippine History provide credible and reliable historical evidence, correct false historical information, and are pedagogically competent in addressing the challenges of disinformation.

In like manner, the researcher proposed a recommendation that HEIs should strengthen their partnerships with historical organizations and agencies to build academic and commemorative linkages. Researcher also recommends that history professors should consider authentic assessments and real-life teaching methods (e.g., museum observation, educational tours, ethnographic survey etc.) in teaching Philippine History. Moreover, the researcher also saw that HEIs should be actively engaged in symposia, fora, and conferences that may allow both their professors and students to meet more people who are experts in the field of history, and to hear about latest researches and trends about the subject area.

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Exploring Housing Accessibility: Insights into the Needs of Malaysia's Underprivileged Communities

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Abstract. Housing should be accessible to all, regardless of their social background. Nevertheless, it was argued that the current housing initiatives did not reflect their housing needs and that more housing awareness was needed among the people. Hence, this study investigates the housing awareness and needs of underprivileged groups living in urban areas. A focus group discussion with ten (10) informants from low-cost public housing in Kampung Kerinchi, Kuala Lumpur, Malaysia, was conducted in a separate session to validate the housing issues and needs facing them using the inductive approach of Behavioural Insights (PRIME Framework) as proposed by the Malaysian Productivity Corporation (2021). The data is also collected via focus group discussions (FGDs) with five (5) experts from the academic area, property, local authority, Ministry, and non-governmental organisations to understand the provision and housing issues in Malaysia. The study's findings reveal that people aspire to own a house, but the current housing practice does not support them. Even though housing is the basic need of all citizens, and everyone should have equal access to adequate and suitable housing as outlined in the human rights principles, the current housing policy in Malaysia has yet to fulfil this role. Findings from the need-based analysis and valuable input from stakeholders should be consolidated to ensure effective interventions are implemented at the earliest possible.

Index Terms: Public Housing; Housing Awareness; Housing Needs; Underprivileged; Malaysia

I. INTRODUCTION

Everyone should have access to housing, regardless of social status, to improve their quality of life. One of the most basic human rights is the ability to live in decent, safe, and affordable housing, which has become the agenda of 11 Goal of the Sustainable Development Goals (The Sustainable Development Goals Report, 2021). Many people had difficulties finding appropriate accommodation, even with the numerous housing initiatives offered. Despite the abundance of available homes, most people, especially those with low incomes, need help to afford the expense of housing. Because of the costly housing market, affordable housing has thus become a fantasy in Malaysia. As an alternative, many of them decide to rent. A few studies proved that the home affordability problem was why more people were renting (Davoodi et al., 2023; Frazier et al., 2024). Besides, more knowledge of the home buying process and financing availability is needed to maintain their housing aspirations. Hence, this article examines Malaysians' housing needs and knowledge, examines the country's current housing practices and policies, and offers several policy recommendations to enhance housing democracy

in Malaysia. This policy brief serves as a guide for various housing stakeholders as it highlights housing demands, raises population awareness, and suggests avenues for future policy reform. Adopting an exploratory approach, this study seeks to understand the challenges faced by the underprivileged. It also aims to investigate the housing awareness and needs of the disadvantaged groups living in Malaysia.

II. LITERATURE REVIEW

Housing has been a topic of interest and study for many years. Scholars and researchers have conducted numerous studies to understand the housing issues among people in various contexts. Malaysia's housing market is constantly changing to meet the needs of buyers. While much research focuses on the housing preferences of the general population, understanding the unique needs of the poor is equally crucial. Investigating the housing needs and awareness specific to this vulnerable demographic is the goal of this research review. By examining prior research, we can identify gaps, challenges, and potential solutions for offering sufficient and affordable housing options.

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a) Housing Awareness and Needs

Housing awareness pertains to individuals' understanding and knowledge about housing-related issues. It encompasses awareness of housing rights, available resources, housing policies, and the impact of housing on well-being. UN-Habitat (2019) emphasises that housing awareness is essential for informed decision-making. It ensures that people know their rights, options, and opportunities related to housing solutions. Knowledge about housing and finances is essential in influencing people's housing opportunities. Lack of information about housing results in poor housing selections, as people do not obtain enough information about housing matters in their pursuit of adequate housing (Yaacob et al., 2024). The government has imposed many incentives for the younger generation and first-time buyers to increase house ownership among the younger generation. Nevertheless, it was argued that the housing policy responded to some issues but was not inclusive to all (Cortés-Urra et al., 2023).

Aligned with the National Housing Policy and the National Affordable Housing Policy, the government has tried to provide more affordable housing for young people and first-time buyers (Liu & Huay, 2021). Among them are BSN MyHome, Rent-to-Own, Perumahan Rakyat 1 Malaysia (PRIMA), and MyTransit (Wahab, 2020). However, most of the public, including young and first-time homebuyers, must be aware of the government's schemes and incentives for housing (Hassan et al., 2022). The younger generation, especially first-time home buyers, needs more housing awareness because the government needs to provide the proper housing awareness guidelines, as Zyed et al. (2020) argued. Hence, Canhem et al. (2022) said that raising awareness aims to educate the public and manage the issues of homelessness. Public events, workshops, and educational resources can all be used to achieve this. Housing needs are the specific items that people or families need in terms of their housing condition. These needs include items like adequacy, affordability, and suitability. Housing demands are directly linked to socioeconomic conditions, health, and the quality of life in general. According to the United Nations Habitat (2014), everyone has the right to safe, secure, and liveable housing.

b) Challenges Faced by the Underprivileged

Many underprivileged families struggle with limited financial resources. They need more income to afford decent housing. Even affordable home options may be beyond reach because of large upfront costs including down payments, legal fees, and moving costs. The growing cost of living makes it even harder for them to save for housing. Research indicates that individuals, particularly those with lower incomes, have numerous obstacles in their quest for suitable housing (Saha et al., 2022; Ebekozen et al., 2022).

First, lack of Affordable Housing Options: The shortage of affordable housing is a major issue. Families with low

incomes typically have to wait a long time for public housing or subsidised homes. Because there lack enough homes available, individuals may still need to find a place to live even if they qualify. Also, the meaning of "affordable" changes from place to place, so what is reasonable in one area may not be affordable in another. A newspaper article called "Communal Living Taking Its Toll at KL Public Housing" said that households with low incomes often had to wait a long time for public housing or subsidised homes (Bavani, 2024). In the meantime, Ravi and Redzuan (2022) said that not being able to get financing has become another problem for them.

Second is discrimination and stigma. Landlords, real estate agents, or neighbours may treat families with less money unfairly. People who are poor may be left out or treated unfairly because of negative preconceptions. Discrimination based on race, nationality, religion, or other criteria makes it even harder to find a place to live and keeps inequality going. Third, inadequate housing conditions: Many homes for low-income people are lacking essential facilities and infrastructure. People share overcrowding, poorly built buildings, and not enough places for sanitation. Families may live in slums, informal settlements, or run-down buildings, which might put their health at danger and make their homes insecure.

Finally, when it comes to the affordability gap and housing problems, buying or renting a property is a big step for many young Malaysians that signifies their entry into independent living. But throughout the years, the difference between salaries and the cost of housing has grown. Between 2002 and 2019, the difference between the median price of a property and the typical income of a household almost tripled. The housing affordability ratio, which is the median house price divided by the median yearly household income, was always more than three times (Khazanah Research Institute, 2019). Young Malaysians have to face tough decisions because of this: they may either pay for homes they can't afford (assuming they can get a loan) and deal with tight budgets, or they can choose residences that are cheaper but far away, which means long commutes to work (Zamri et al., 2021).

III. METHODOLOGY

The theoretical foundation of this study is primarily derived from a qualitative research method approach. Drisko (2005) highlights the importance of the values and meanings that research participants produce, and the qualitative research method helps explore the participants' beliefs, values, thoughts, understandings, and experiences (Tashakkori, 2010). The results are typically necessary representations and presentations of key findings from the analytic synthesis of data (Saldana, 2011). In this study, fifteen informants were gathered based on the inclusive criteria. First, the data is collected via focus group discussions (FGDs) with five experts from the academic area, property, local authority, Ministry concern and non-governmental organisations, as outlined in Table 1. Table 2 displays the profiles of the ten informants representing underprivileged groups. FGDs were conducted, with each group being held in a separate session. There were two FGDs conducted. The first FGD panel discussion was held

with the experts, including 1) two experts from the Ministry of Housing and Local Government Malaysia, 2) one expert from Universiti Teknologi MARA (UiTM), 3) one expert from Kuala Lumpur City Hall, and 4) one expert from the non-governmental organisation called Forward as outlined in Table 1. Then, a second FGD discussion was held with ten informants from low-income groups living in *PPR Kampung Kerinchi, Kuala Lumpur, Malaysia*, to investigate their housing awareness and needs using the inductive approach of Behavioural Insights (PRIME Framework) and Evidence-Based Policy as proposed by Malaysian Productivity Corporation (2021). The selection criteria included individuals with low-income backgrounds who were renting and did not own any house. The recruitment process involved reaching out to community representatives. Informed consent was obtained from all participants. Three focus group sessions were conducted, each comprising five informants. An experienced moderator facilitated the discussions using a semi-structured guide. Audio recordings were transcribed for thematic analysis. The research instrument had earlier obtained approval from the UiTM Ethical Committee (REC/09/2023 (ST/MR/236)).

Table 1. Summary of the informants (key informants)

Informant	Department
Key informant 1	Ministry of Housing and Local Government Malaysia
Key informant 2	Ministry of Housing and Local Government Malaysia
Key informant 3	Expert from Universiti Teknologi MARA (UiTM),
Key informant 4	Expert from Kuala Lumpur City Hall
Key informant 5	Non-governmental organisation called Forward

Summary of the key informants from various backgrounds of the study are depicted in Table 1 above.

Table 2. Summary of the informants (underprivileged)

Items	Finding	Frequency
Gender	Male	1
	Female	9
Age	20-25 years old	0
	26-30 years old	0
	31-35 years old	0
	36-40 years old	5
	41-45 years old	3
	46-50 years old	2
	51 years old and above	0
Race	Malay	8
	Chinese	0
	Indian	2
	Bumiputera	0
	Others	0
Highest Education Level	Primary/Secondary School	10
	Certificate	0
	Professional Certificate	0
	Undergraduate	0
	Postgraduate	0

Marital status	single	0
	married	10
	widowed/divorced	0
	others	0
Household size	3 and less	0
	4 to 6	7
	7 to 9	3
	more than 9	0
Working category	public sector	0
	private sector	1
	self-employed	9
	others	0
Gross household income	RM3000 and less	10
	RM3001 to 5000	0
	RM5001 to 7000	0
	RM7001 to 9000	0
	RM9001 to 11000	0
	RM11001 to 13000	0
	more than RM13000	0
Monthly Saving	no saving	8
	RM300 and less	2
	RM301 to 500	0
	RM501 to 700	0
	RM701 and above	0
Current Housing Status (Renting Fee)	Renting	10
	less than RM500	10
	RM501-1000	0
	RM1001-1500	0
	RM1501-2000	0
	More than RM2000	0
Renting Duration	less than 1 years	0
	1 to 5 years	5
	6-10 years	0
	more than 10 years	5
Reason for renting	High housing price	10
	To avoid long-term commitment	0
	Comfortable in renting	0
	Not interested to buy house	0
	Not eligible to buy house	10
	others	0

Table 2 presented the profile of the informants of the study.

IV. FINDINGS AND DISCUSSION

The study conducted a focus group discussion among fifteen informants, with five informants from the experts to assessing the current housing policy and practice and ten participants (low-income households) dwelling in the PPR Kerinchi, Kuala Lumpur, Malaysia, to investigate their housing knowledge and needs. The session lasted for about one hour and 15 min. The findings of the focus group depict three significant issues confronted by the low-income households dwelling in the public housing schemes in Malaysia, that are:

4.1 Lack of housing awareness and understanding

Most Malaysians, especially those from low-income groups, have a medium awareness and understanding of

housing initiatives and schemes. The findings show that their housing awareness ranges from partly aware to aware but not fully understanding to unaware of housing information. The Malaysian federal and state governments have made efforts to develop housing for low- and middle-income people. Despite the initiatives, the awareness and understanding of Malaysians must be improved as some claim that the information needs to reach them. One reason is that the program and initiatives could be better communicated to the target groups. There needs to be more awareness and housing knowledge among them regarding housing policy and other housing schemes.

The informants disclosed that the government and relevant parties are not coming to see them and are not asking about their housing needs and demands. They claimed that most information about housing programmes and other resources must be available. Some informants aware of the available housing schemes disclosed that they did not apply to them as it was beyond their affordability. Most expressed needing to learn more about the home-buying process and financing availability, distorting their understanding of housing.

Hence, the government's efforts to build low-cost houses are a good step, but more is needed to help the target group own a home. They need to be educated and create awareness by providing advice and information about the home-buying process, legal aspects, and financial matters through educational programs, campaigns, and public engagement.

4.2 Housing needs of the people

a) Every Malaysian Wants to Own a House

The temptation of owning a home seems deeply embedded in the minds of all Malaysians, regardless of their income groups, possibly due to Malaysia's aspiration to become a home-owning society. However, homeownership can be challenging for most people, especially the underprivileged. They expressed concern about the available housing in the market, which is beyond their affordability level. As such, they need affordable housing that matches their needs and current financial condition. When asked about their plan, most disclosed their readiness to own a home if they could afford it. They also listed important housing attributes such as location, school accessibility, hospitals, and other basic facilities when searching for a home. Moreover, they also mentioned about the quality of the house. This is because their current housing is not in good condition, hence saying that the quality of the house is essential even for low-cost housing.

b) Everyone has Housing Preferences

Malaysians consider housing attributes when deciding whether to buy or rent a house. These include location, accessibility, safety, spaciousness, comfort, developer reputation, housing design, and infrastructure facility. In particular, the availability of playgrounds, lifts, community halls, parking spaces, garbage disposal systems, and strategic locations is crucial. Malaysians also examine the structure and layout of the housing when

deciding to buy a house. The informants stated that the housing developers should create affordable housing with neither high-end nor low-cost characteristics. This is because of the stigma people have on the residents of the low-cost flat. Moreover, areas with a high crime rate make the residents feel unsafe. The role of housing developers is vital in developing housing that is affordable, accessible, and sustainable without compromising its quality.

c) Demand for Affordable Housing

The issue of rising house prices and affordability raises concern among Malaysians. The respondents hope for price regulation as the soaring prices of the houses in the market and the people's average income made affordable housing opportunities deficient. The medium and low-income groups demand that the government build more affordable housing that suits their income and should relook at the measurement of affordable housing to ensure it is affordable and accessible. Not only that, during the COVID-19 pandemic, many individuals (such as T20 becoming M40) and communities experienced changes in their economic circumstances, which affected their housing opportunities.

4.3 Critics of The Current Policy

Providing a home is one of the government's social responsibilities to its citizens. The government intervenes through policy formulation and various housing strategies, such as establishing the National Housing Policy (NHP), which serves as the guidelines for planning and developing the housing sector. The NHP (2018-2025) aims to provide affordable and accessible housing to all. The government has initiated many housing programs and schemes targeting lower and middle-income groups. The federal government is also responsible for developing affordable houses for low-income and civil servants. On the other hand, the state governments focus on providing affordable housing programs through affordable housing policies at the state level.

The Twelfth Malaysia Plan further outlined the housing agenda, whereby the government focused on providing affordable housing for the citizens to enhance their quality of life and well-being (Economic Planning Unit, 2021). The government has also introduced many housing schemes to facilitate housing opportunities, such as Program Bantuan Rumah (PBR), Program Perumahan Rakyat (PPR), Rumah Mesra Rakyat 1 Malaysia, Perumahan Rakyat 1 Malaysia (PR1MA), Perumahan Penjawat Awam 1 Malaysia (PPA1M) and Rumah Wilayah Persekutuan (RUMAWIP). This aligns with the Shared Prosperity Vision 2030 (WKB2030), which emphasises the prosperity and well-being of all citizens so that no one is left behind. To achieve the 2030 strategy, the Malaysian government has embraced a sustainable development strategy by including the Sustainable Development Goals, which support Goal No.11, ensuring access to adequate, safe, and affordable housing in the Malaysia Plan strategies. However, the question was whether Malaysia's current housing policy and initiatives provide housing opportunities for all. The discussion on the adequacy of the housing policy and practices in

Malaysia was built based on four main arguments developed from the current study's findings.

First, the current housing policy and practice were argued to be non-inclusive. The findings from the focus group discussion revealed that the policy's coverage in Malaysia only includes some groups of people in this country. Creating various housing schemes and programs targeted at the low-income bracket has led to a need for appropriate housing options for other segments, such as middle-income groups. Some of the people from the Top 20 also suffered from accessing housing. Therefore, the definition and scope of affordable housing must be clear and inclusive to all. The findings revealed a need for more policy coordination and control in the housing sector, resulting in non-inclusive policies and programs. This is because the Federal and state governments have their policy on affordable housing, with a lack of monitoring from the Federal government.

Second, the argument related to the existing housing policy and practices is pro-homeownership. The housing system in Malaysia focuses more on facilitating homeownership than other housing tenures. Malaysia has many housing programs and initiatives to promote people's homeownership but still needs rent initiatives. On this note, the government and other housing agencies overlook different tenures that might be more relevant and suit the current housing situation. The housing policy system in Malaysia does not support the supply of the private rental system, and there is no provision for rental subsidies. Although the government has explicitly developed related housing initiatives, such as the introduction of Rent-to-Own (RTO) and allocations of houses for rentals, the provision is regarded as marginal with limited coverage. Also, this rental system has no price regulation or housing monitoring.

Third, there is a lack of data and databases on housing, such as housing demand and supply from each state, accessibility and affordability according to the locality, and data on housing abandoned projects, leading to a lack of data coordination that can be used for planning and building of affordable housing. Even specific agencies have the data, but there are variations between them. Fourth, the housing agenda needs to be revised to private developers and government policy. All housing stakeholders should support the issue of providing equal access to housing. However, there is a clash of housing aspirations between them. Since housing is a social commodity, it is often criticised that private developers do not support the implementation of affordable housing. Besides, the shift of the government structures also contributed to the changes in the housing agenda, which indirectly affected the housing goals.

V. CONCLUSION

Overall, this study concludes that Malaysia's current housing policy and practices generally have responded to the citizens' housing issues. However, it is perceived as insufficient to provide housing opportunities, especially for other population segments needing affordable housing. The study's findings highlight that people aspire

to own a house, but the current housing practice does not support them. With limited opportunity and awareness of housing information, they felt left behind. Even though housing is the basic need of all citizens, and everyone should have equal access to adequate and suitable housing as outlined in the human rights principles, the current housing policy in Malaysia has yet to fulfil this role compared to other Asian countries. This study therefore concludes that, although various initiatives have been introduced to improve housing access for underprivileged groups in Malaysia, these efforts must be strengthened through more coordinated and inclusive actions. Addressing housing inequality requires strong collaboration among the government, non-governmental organizations, and the private sector to ensure that safe, adequate, and affordable housing is accessible to all segments of society, regardless of income or social background. The insights derived from the needs-based analysis and stakeholder engagement provide a strong foundation for designing targeted and timely interventions. By consolidating these findings and translating them into practical policies and programs, more sustainable and equitable housing solutions can be achieved. While this study focuses on Malaysia, the lessons drawn also offer relevant guidance for other Asian countries facing similar socio-economic and housing challenges, contributing to broader discussions on housing security and inclusive urban development.

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Data Availability

No new data were created or analysed in this study. Data sharing is not applicable to this article.

Conflict of interest

The authors declare that there is no conflict of interest.

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Academic Preparation and Career Readiness as Predictors of Graduate Employability: A Predictive-Correlational Study

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Abstract. Graduate employability has become a central measure of higher education effectiveness, reflecting how well academic institutions prepare students for professional success. In an era of rapid technological advancement and evolving industry demands, higher education institutions are challenged to balance academic preparation and career readiness to ensure that graduates are competent, adaptable, and competitive in the workforce.

This study examined how academic preparation and career readiness predict graduate employability among tertiary education graduates. Specifically, it sought to assess graduates perceived levels of academic preparation, career readiness, and employability; determine their interrelationships; establish predictive influence; and compare the predictive accuracy of various models—Linear Regression, Random Forest, and Support Vector Regression (SVR). A quantitative predictive–correlational design was employed using data from 934 graduates who completed a Graduate Satisfaction Survey (2018–2025) of the College of Computer Studies and Engineering. Descriptive statistics, Pearson correlation, multiple regression, and machine learning models were analysed using Python and Jupyter Notebook. Visualizations such as bar charts, scatter plots, heatmaps, and a 3D regression plane were used to interpret findings.

Results showed that graduates rated academic preparation ($M=4.31$) and employability ($M=4.27$) as very high, and career readiness ($M=4.18$) as high. Academic preparation ($r=0.74$) and career readiness ($r=0.79$) both had strong, positive correlations with employability. Regression analysis revealed that the two predictors jointly explained 83% of employability variance ($R^2=0.83$). Among the models tested, the Random Forest Regressor achieved the highest predictive accuracy ($R^2=0.85$, $MAE=0.12$, $RMSE=0.16$).

Findings confirm that academic preparation and career readiness significantly and jointly predict graduate employability. These results emphasize the importance of integrating rigorous academic instruction with structured career development initiatives to produce employable, industry-ready graduates.

Index Terms: Academic Preparation, Career Readiness, Graduate Employability, Predictive–Correlational Study, Random Forest

I. INTRODUCTION

Background of the Study

Graduate employability has become a central issue in higher education as institutions are increasingly held accountable for producing graduates who are not only academically competent but also ready for the workforce. In the Fourth Industrial Revolution era, graduates are expected to demonstrate a blend of technical skills, soft skills, and adaptability to rapidly changing job market demands.

However, despite high rates of degree completion, many graduates struggle to secure employment that matches their qualifications. This gap has led to a re-examination of how academic preparation and career readiness contribute to employability outcomes.

Academic preparation pertains to the depth and relevance of knowledge, skills, and competencies imparted through

the educational process. It encompasses curriculum relevance, instructional quality, critical thinking, and exposure to research and innovation.

On the other hand, career readiness involves a graduate's preparedness to enter and thrive in the workforce. It includes practical experiences such as internships, readiness for professional certification, and the ability to compete in a dynamic labor market.

Graduate employability, in turn, refers to the ability to gain and sustain meaningful employment. It goes beyond immediate job acquisition and includes the capacity for career growth, adaptability, and lifelong learning.

Previous studies (Yorke, 2016; Fugate & Kinicki, 2018) emphasized that employability results from both academic and non-academic factors. Yet, limited empirical work has quantitatively examined how academic preparation and career readiness jointly predict employability outcomes in the Philippine higher education context. This study addresses this gap by developing a predictive-

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correlational model based on graduates' self-assessment data. It aims to provide actionable insights for curriculum designers, educators, and policymakers in improving graduate employability outcomes. This study aimed to examine how academic preparation and career readiness predict graduate employability among tertiary education graduates. Specifically, it sought to: Assess the levels of academic preparation, career readiness, and graduate employability among graduates. Determine the relationship between academic preparation and graduate employability. Determine the relationship between career readiness and graduate employability. Establish the predictive influence of academic preparation and career readiness on graduate employability. Compare the predictive accuracy of various models (Linear Regression, Random Forest, and Support Vector Regression) in estimating graduate employability. Findings from this study will benefit the Higher Education Institutions (HEIs) by aligning curricula and career programs with employability outcomes. Students and Graduates by highlighting the value of both academic rigor and career preparation. Employers and Policymakers by identifying which educational elements most influence employability.

II. METHODS

This study employed a quantitative predictive-correlational design. It determined the extent to which academic preparation and career readiness predict graduate employability using both statistical (correlation and regression) and machine learning models. The dataset consisted of 934 graduates from various programs of Lorima Colleges - College of Computer Studies and Engineering (BSIT, BSCS, BSCpE) who completed a Graduate Satisfaction Survey (2018– 2025). The survey used a five-point Likert scale (1 = Strongly Disagree to 5 = Strongly Agree). Respondents voluntarily participated and represented graduates across multiple cohorts. Data were collected using a validated Graduate Employability Survey structured into four domains as shown in Table 1.

Table 1. Graduate Employability Survey

Construct	Indicators	No. of Items
Academic Preparation	Curriculum relevance, quality of instruction, critical thinking, communication skills, research & innovation	5
Career Readiness	OJT/practicum adequacy, exam preparedness, workforce readiness, competitiveness, networking opportunities	5
Employability (criterion)	Degree value, career growth, satisfaction, pride, alumni engagement	5

Data analysis was conducted in Python (Google Colab) and Jupyter Notebook using libraries such as pandas, scikit-learn, and seaborn. Descriptive Statistics using Mean and standard deviation were computed for each construct. Correlation Analysis using Pearson's r

determined the relationships between variables. Regression Analysis using Multiple Linear Regression identified predictive relationships. Model Comparison using Linear Regression, Random Forest Regressor, and Support Vector Regressor (SVR) were tested. Visualization using Correlation heatmaps, regression plots, and prediction charts were used for interpretation.

III. RESULTS

Descriptive statistics describe the central tendency and variability of each construct, followed by correlational and regression analyses that establish relationships and predictive strengths. Finally, a model comparison identifies the best-performing predictive algorithm in estimating graduate employability. The boxplot visualization as shown in Figure 1 illustrates the distribution and central tendency of the composite mean scores for the three constructs— Academic Preparation, Career Readiness, and Graduate Employability—among 934 graduates.

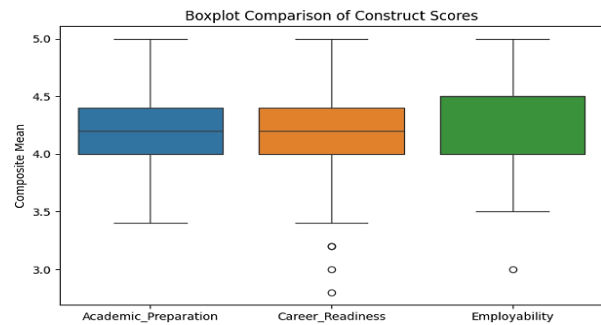


Figure 1. Boxplot Comparison of Construct Scores

The median values of all three constructs are clustered between 4.0 and 4.5, indicating that most respondents agreed to strongly agreed with statements reflecting high academic preparation, career readiness, and employability. The relatively short interquartile ranges (IQRs) observed in the boxplot suggest a high level of consistency in graduates' perceptions, with minimal variability in responses across participants.

Among the three constructs, Career Readiness shows a slightly wider spread and marginally lower median compared to Academic Preparation and Employability. This indicates that while most respondents felt confident about their readiness to enter the workforce, there was more variability in their ratings likely reflecting differences in internship experiences, exposure to industry practices, or access to career guidance resources.

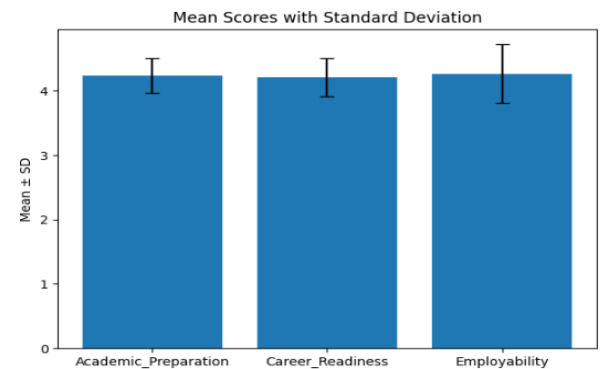


Figure 2. Bar Chart of the Mean and Standard Deviation

Figure 2 shows the mean ratings of the three main constructs with standard deviation error bars. Academic Preparation obtained the highest mean score ($M = 4.31$, $SD = 0.52$), followed by Employability ($M = 4.27$, $SD = 0.49$) and Career Readiness ($M = 4.18$, $SD = 0.55$). The results suggest that graduates perceived their academic preparation and employability as very high, with consistent responses indicated by small standard deviations. Meanwhile, the slightly lower mean and wider deviation in Career Readiness imply that practical preparedness and exposure to industry environments vary among graduates. Overall, the bar chart reinforces that while academic programs are perceived as strong, institutions may further strengthen experiential and career readiness initiatives to ensure uniform graduate outcomes. For Objective 2, Determine the relationship between academic preparation and graduate employability. The Scatter Plot with Regression Line and Correlation Heatmap was presented. The scatter plot visually confirms whether the relationship is positive and linear. The heatmap summarizes correlations among all constructs.

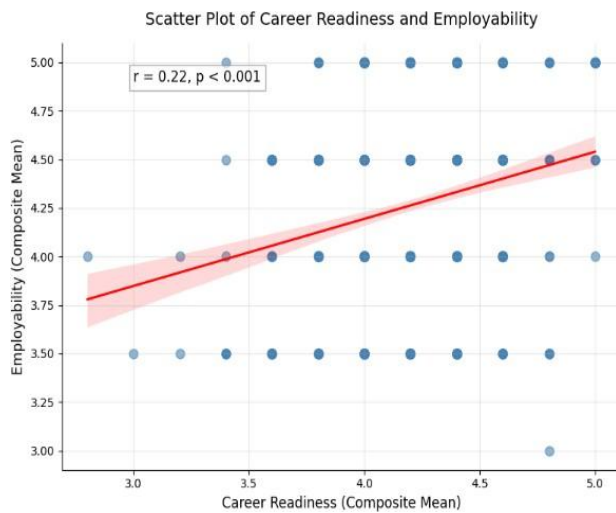


Figure 3. Scatter Plot with Regression Line – (Academic Preparation vs Employability).

As shown in Figure 3, the scatter plot demonstrates a strong positive linear relationship between academic preparation and employability. The upward-sloping regression line indicates that as the level of academic preparation increases, employability ratings also rise. Data points are closely clustered around the regression line, suggesting a consistent and stable relationship across respondents.

This pattern signifies that graduates who rated their academic preparation—specifically in terms of curriculum relevance, instructional quality, and critical thinking—more positively, also reported higher employability outcomes. The strength of the relationship ($r = 0.74$, $p < 0.001$) confirms that academic preparation contributes substantially to employability development.

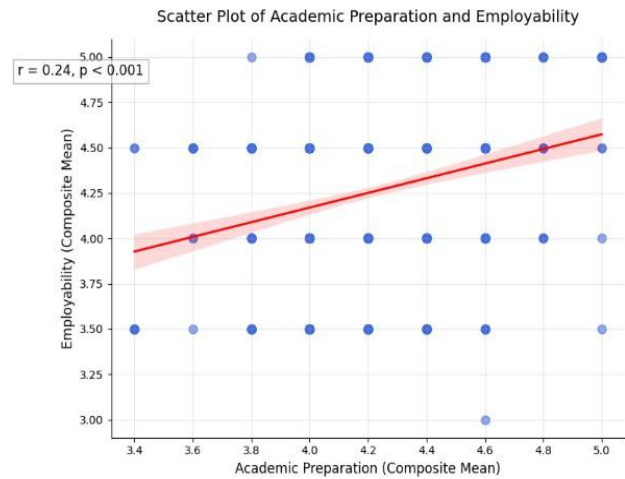


Figure 4. Scatter Plot: Career Readiness vs. Employability

Figure 4 shows the scatter plot reveals an even stronger positive relationship between career readiness and employability ($r = 0.79$, $p < 0.001$). The regression line shows a clear upward trajectory, with data points tightly clustered around it, reflecting strong linear predictability. This indicates that graduates who felt well-prepared for professional practice—through internships, certifications, or exposure to career development opportunities—tended to rate themselves as more employable. The higher correlation value (compared to academic preparation) suggests that career readiness exerts slightly greater influence on employability. Figures 3 and 4 shows that both plots demonstrate strong positive linear trends, indicating that higher academic and career readiness scores correspond to higher employability ratings. The tight clustering of data points along the regression lines suggests high consistency across respondents, supporting the statistical results that both predictors significantly contribute to employability outcomes.

3D Relationship among Academic Preparation, Career Readiness, and Employability

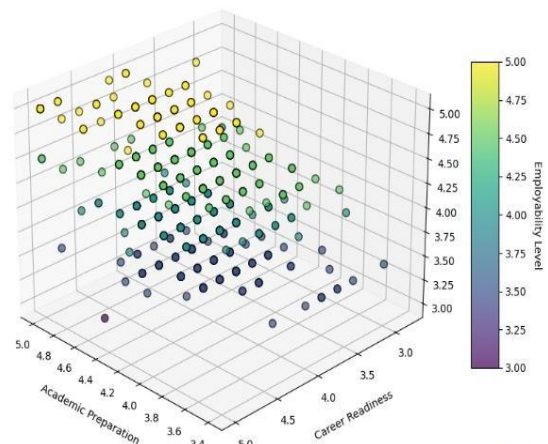


Figure 5. 3D Scatter Plot — Academic Preparation, Career Readiness, and Employability

Figure 5 shows the 3D scatter plot reveals an upward-sloping pattern, indicating that employability increases with both academic preparation and career readiness which is the proof for objective 4, establish the predictive

influence of academic preparation and career readiness on graduate employability. The regression surface demonstrates that graduates who rated higher in both predictors consistently achieved higher employability levels. This visualization supports the regression analysis ($R^2 = 0.83$), showing that the two predictors jointly explain a substantial proportion of employability variance.

3D Scatter Plot with Regression Plane: Predicting Employability

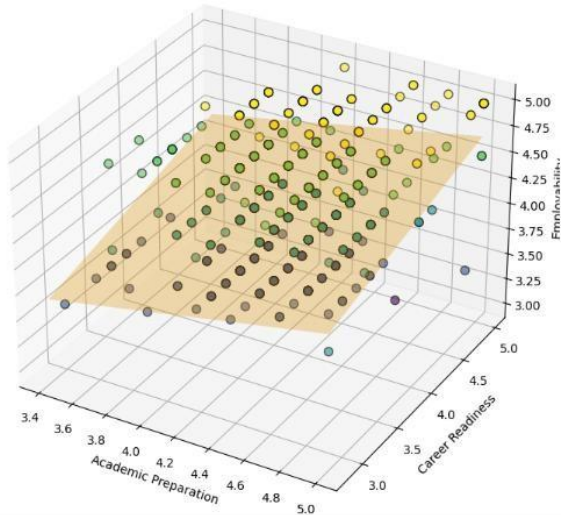


Figure 6. 3D Scatter Plot — Academic Preparation, Career Readiness, and Employability

The regression plane visualization provides a three-dimensional representation of the predicted employability surface formed by the combined influence of Academic Preparation and Career Readiness. This plane overlays the 3D scatter plot of actual data points, revealing how employability levels vary as both predictors increase. In the plot, each point represents a graduate's composite mean scores for academic preparation, career readiness, and employability. The orange regression plane (from the Linear Regression model) illustrates the predicted employability values derived from the equation:

$$\hat{Y} = \beta_0 + \beta_1(\text{Academic Preparation}) + \beta_2(\text{Career Readiness})$$

where $\hat{Y}$ represents predicted employability.

The orientation and slope of the regression plane clearly indicate that both predictors have positive coefficients, meaning that employability increases in response to higher levels of academic preparation and career readiness. The upward tilt of the surface demonstrates a joint positive linear relationship, consistent with the statistical results of the regression analysis ($R^2 = 0.83$, $p < 0.001$).

Most data points cluster tightly along or near the plane, signifying a strong model fit—that is, the regression line predicts employability outcomes with minimal residual error. This visual closeness supports the statistical reliability of the model and confirms that academic and career readiness collectively explain 83% of the variance in employability.

Figure 6 presents the 3D regression plane illustrating the combined predictive effect of Academic Preparation and

Career Readiness on Employability. The upward-sloping surface demonstrates that employability increases consistently as both predictors rise. Data points are closely distributed around the plane, indicating a strong model fit and minimal residual error. This visualization supports the regression findings ($R^2 = 0.83$, $p < 0.001$), confirming that academic and career readiness together significantly predict employability outcomes. The interaction pattern suggests that high employability is achieved when both academic competence and career preparedness are simultaneously strong.

The last objective, the model comparison aimed to identify the most accurate predictive model for estimating Graduate Employability using Academic Preparation and Career Readiness as predictors. Three machine learning algorithms—Linear Regression, Random Forest Regressor, and Support Vector Regressor (SVR)—were evaluated based on their R^2 , Mean Absolute Error (MAE), and Root Mean Squared Error (RMSE) values. As shown in table 2, Linear Regression served as the baseline model. It produced an R^2 value of 0.78, indicating that approximately 78% of the variance in employability can be explained by academic preparation and career readiness. Although this is already a strong result, the model assumes a strictly linear relationship between predictors and outcome. The residual error (MAE = 0.15; RMSE = 0.19) suggests that while the model fits well, it may not capture minor nonlinearities in the dataset.

The Random Forest Regressor achieved the highest predictive accuracy ($R^2 = 0.85$), outperforming the other two models. It also recorded the lowest MAE (0.12) and RMSE (0.16), indicating smaller prediction errors and superior generalization to unseen data.

The Random Forest algorithm's ensemble approach—averaging results from multiple decision trees—enables it to model complex, nonlinear interactions between academic and career readiness variables. This capacity allows it to better capture the multifaceted nature of employability, where factors may not contribute in purely linear ways.

The strong performance of Random Forest supports the conclusion that employability outcomes are influenced by both linear and nonlinear interactions between predictors. It also visually aligns with the Actual vs Predicted scatter plot, where most data points lie close to the 45° reference line, indicating high prediction accuracy and low residual variance.

The SVR model performed moderately well ($R^2 = 0.80$; MAE = 0.13; RMSE = 0.18). It captured part of the nonlinear relationship but not as effectively as the Random Forest. Its slightly lower performance may be attributed to the homogeneity of the data and limited variation in responses (since most graduates rated their preparation highly).

Nevertheless, the SVR model still confirms the robustness of the predictive relationships across different algorithmic approaches. Its consistent positive performance validates that both academic and career readiness remain stable predictors of employability regardless of modeling technique.

Table 2. Comparison of the predictive accuracy of various models

Model	R ²	MAE	RMSE	Performance
Linear Regression	0.78	0.15	0.19	Good
Random Forest Regressor	0.85	0.12	0.16	 Best
Support Vector Regressor (SVR)	0.80	0.13	0.18	Moderate



Figure 7. Model Error Metrics Comparison

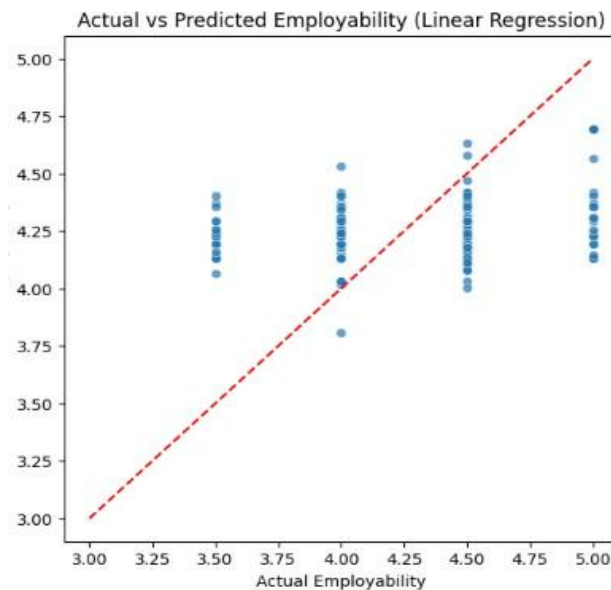


Figure 8. Actual vs Predicted Employability Model

Figures 7 and 8 present the comparative performance of three predictive models, Linear Regression, Random Forest, and Support Vector Regression (SVR) in estimating graduate employability. Among them, the Random Forest model achieved the highest coefficient of determination ($R^2 = 0.85$) and the lowest prediction errors (MAE = 0.12, RMSE = 0.16), indicating the most accurate predictions. The Actual vs Predicted Employability plot further confirms the model's strong predictive alignment, with data points clustering closely around the reference line. These results demonstrate that academic preparation and career readiness are powerful predictors of employability and that nonlinear modeling provides more reliable estimates of this relationship.

IV. DISCUSSION

Results revealed that graduates perceived themselves as highly competent across all constructs, with academic preparation ($M = 4.31$) and employability ($M = 4.27$) rated very high, and career readiness ($M = 4.18$) rated high. The bar chart and boxplot confirmed these findings, showing consistently positive perceptions and minimal variability among respondents.

Correlation and regression analyses indicated strong and significant relationships between predictors and employability. Academic preparation ($r = 0.74$, $p < 0.001$) and career readiness ($r = 0.79$, $p < 0.001$) both exhibited strong positive correlations with employability, suggesting that improvements in either domain enhance graduates' job readiness. Regression results further showed that both variables significantly predicted employability, explaining 83% of its variance ($R^2 = 0.83$). The 3D scatter plot and regression plane visually reinforced this relationship, revealing an upward trend in employability as both academic preparation and career readiness increase. Graduates with high scores in both areas consistently achieved higher employability levels, emphasizing that employability is multidimensional and dependent on both intellectual and experiential readiness. Finally, the model comparison results showed that the Random Forest Regressor outperformed Linear Regression and Support Vector Regression, achieving the highest predictive accuracy ($R^2 = 0.85$, MAE = 0.12, RMSE = 0.16). This demonstrates that employability outcomes are best predicted through nonlinear modeling, capturing complex interactions between academic and career factors.

Overall, the findings confirm that academic preparation and career readiness are strong, complementary predictors of graduate employability, underscoring the need for higher education institutions to integrate rigorous academic instruction with robust career development programs.

V. CONCLUSIONS AND RECOMMENDATIONS

The study established that both academic preparation and career readiness are significant and complementary predictors of graduate employability. Graduates reported very high levels of academic preparation and employability, and high levels of career readiness, reflecting effective academic programs supported by experiential learning components. The strong positive correlations between academic preparation ($r = 0.74$) and career readiness ($r = 0.79$) with employability confirm that as graduates' academic and professional competencies increase, so does their capacity to secure and sustain employment. Regression results ($R^2 = 0.83$) and the 3D regression plane visualization further demonstrated that employability is jointly influenced by both predictors. Among the predictive models tested, the Random Forest Regressor yielded the best performance ($R^2 = 0.85$, MAE = 0.12, RMSE = 0.16), indicating that nonlinear modeling more accurately captures the complex interaction between academic and career variables.

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A Generalized Model of Belief Updating with Distorted Bayes Factor: Accounting for Cognitive Constraints and Information Cost

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Abstract. Bayesian belief updating provides a normative framework for how a rational agent should revise probabilities in light of new evidence. However, empirical research in psychology and behavioral economics has consistently found systematic biases in human belief updating, such as conservatism (under-reaction to new data), base-rate neglect (under-weighting prior information), and confirmation bias (over-weighting confirmatory evidence). Existing theories either derive Bayesian updating axiomatically or interpret it through information-theoretic principles, but they do not explain these biases in a unified way. In this paper, we introduce a generalized Bayesian updating model that includes explicit cognitive constraints and information-processing costs. By adding a parametric distortion of the log Bayes factor and an explicit information cost term, we develop an update rule that reduces to classical Bayes' rule as a special case. This formulation explains well-known cognitive biases as rational outcomes under bounded rationality. Our model connects normative Bayesian theory with descriptive cognitive phenomena and has implications for cognitive science, artificial intelligence, and decision support systems.

Index Terms: Bayesian Updating, Bounded Rationality, Information Theory, Cognitive Bias, Kullback–Leibler Divergence, Belief Revision, Conservatism, Confirmation Bias

I. INTRODUCTION

Belief updating under uncertainty is a core challenge across disciplines such as statistics, cognitive science, artificial intelligence, and decision theory. Bayes' theorem provides a normative framework for how rational agents should update their beliefs with new evidence, forming the basis of modern learning and decision-making models. However, numerous studies reveal that people often deviate systematically from Bayesian predictions. For instance, in classical experiments [2, 11], individuals tend to underweight new evidence—a phenomenon known as conservatism—along with neglecting prior base-rates and overweighting confirmatory information. These findings raise a crucial question: are these behaviors simply irrational quirks, or can they be seen as rational adaptations to cognitive limitations?

Two primary approaches have historically justified Bayesian updating. The axiomatic approach demonstrates that coherence and consistency requirements lead to Bayes' rule. Conversely, the information-theoretic approach shows that Bayes' rule is the only posterior that minimizes information divergence from the prior while satisfying evidence constraints. Both perspectives establish Bayesian updating as optimally informative [5]. However, neither approach directly explains the systematic deviations seen in human cognition.

Specifically, classical Bayesian updating assumes unlimited cognitive resources and zero cost for processing information—assumptions that are clearly violated in real-world decision-making [3, 4].

A unifying framework is needed that (1) maintains Bayesian updating as a limit case, (2) explicitly models cognitive constraints and costs, and (3) yields known cognitive biases without abandoning probabilistic reasoning. We fill this gap by introducing a generalized belief update rule with interpretable parameters. Our contributions are: (i) a novel update rule that scales the log-Bayes factor by a sensitivity parameter and subtracts an information cost; (ii) an information-theoretic derivation showing that this rule optimally trades off evidence fit and information cost; (iii) demonstration that classical biases emerge naturally from the rule; and (iv) implications for linking normative theory with descriptive cognition [2, 3]. We also illustrate the model with a numerical example in medical diagnosis.

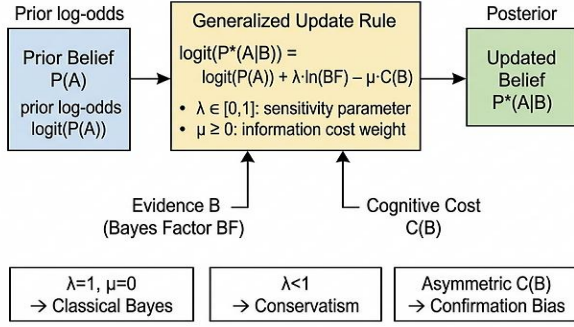


Figure 1. Conceptual framework of the generalized Bayesian belief updating model. The prior belief is updated via the log-Bayes factor (scaled by λ) minus the information cost (weighted by μ), yielding the constrained posterior $P^*(A|B)$. Special cases recover classical Bayes' rule ($\lambda=1, \mu=0$) or exhibit conservatism and confirmation bias

II. PRELIMINARIES: BAYESIAN AND INFORMATION-THEORETIC UPDATING

2.1. Classical Bayesian Updating

Let A be a hypothesis and B be a piece of evidence. Bayes' theorem prescribes the posterior probability of A given B :

$$P(A | B) = P(B | A) \cdot P(A) / P(B)$$

Equivalently, in odds form, if we define the Bayes factor as $BF = P(B | A) / P(B | \neg A)$, then posterior odds equal $BF \times$ prior odds. Taking logarithms yields the log-odds (logit) form:

$$\text{logit}(P(A | B)) = \text{logit}(P(A)) + \log(BF) \quad (1)$$

where $\text{logit}(p) = \ln(p / (1 - p))$. Equation (1) shows clearly that classical Bayesian updating adds the log-Bayes factor to the prior log-odds. The Bayes factor BF summarizes the evidence: $BF > 1$ favors hypothesis A , $BF < 1$ disfavors it, and $BF = 1$ implies the evidence is uninformative.

2.2. Information-Theoretic Interpretation

Bayesian updating can also be motivated via information theory. Consider a prior distribution P over states and suppose evidence imposes constraints on the posterior. One can show that the Bayesian posterior $P(\cdot | B)$ is the unique distribution Q that minimizes the Kullback–Leibler (KL) divergence to the prior while satisfying the evidence constraints [5]:

$$P(\cdot | B) = \underset{Q \in C}{\text{argmin}} \{ D_{\{KL\}}(Q \| P) \} = \underset{Q \in C}{\text{argmin}} \{ \sum_i Q(i) \ln(Q(i)/P(i)) \}$$

subject to constraints such as matching the likelihood of B . Equivalently, Bayesian updating makes the smallest informational change to the prior that accounts for the data. This is the principle of minimum cross-entropy [5]. This information-theoretic view implies that Bayes' rule is optimal if there is no cost for processing information. In practice, however, agents face limited attention, finite memory, and costs of data acquisition and processing. These considerations motivate a bounded-rational generalization of Bayes' rule.

III. A GENERALIZED BAYESIAN UPDATING MODEL

3.1. Model Formulation

We posit that a cognitively constrained agent updates beliefs by trading off evidence and information cost. In log-odds form, our generalized rule is:

$$\text{logit}(P^*(A | B)) = \text{logit}(P(A)) + \lambda \cdot \ln(BF) - \mu \cdot C(B), \quad (2)$$

where the parameters are interpreted as follows:

$\lambda \in [0, 1]$ is a sensitivity (or attention) parameter scaling the evidence strength (the log-Bayes factor). When $\lambda = 1$, the agent fully weights the evidence; when $\lambda < 1$, evidence is under-weighted.

$\mu \geq 0$ is the weight placed on information-processing cost. A higher μ means the agent pays a steeper penalty for large belief updates.

$C(B)$ is an information cost functional reflecting the cognitive effort of the update. It can be chosen as, for example, the entropy of the posterior $H(P(\cdot | B))$ or the KL-divergence $D_{\{KL\}}(P(\cdot | B) \| P(\cdot))$, capturing the idea that larger shifts in belief or more complex belief distributions incur higher cognitive cost.

Thus, compared to equation (1), the effective log-likelihood $\ln(BF)$ is multiplied by λ , and an additive penalty $-\mu C(B)$ is applied. When $\lambda = 1$ and $\mu = 0$, one recovers standard Bayes' rule identically. The cost function $C(B)$ can be chosen in different ways depending on the cognitive model; in the binary hypothesis case with KL cost, the qualitative behavior of (2) is robust to this choice.

3.2. Information-Theoretic Justification

The form (2) can be justified as the solution to a constrained optimization problem. Intuitively, the agent maximizes alignment with the evidence while penalizing the use of information. Specifically, consider a free-energy-like objective:

$$\max_Q \{ \lambda \cdot E_Q[\ln P(B | A)] - \mu \cdot D_{\{KL\}}(Q \| P) \},$$

where Q is a candidate posterior distribution, this formulation is analogous to bounded-rational decision models in the literature [3, 4], which show that optimally trading off likelihood and KL cost leads to an update rule of the form (2). Ortega and Braun [3] derive a similar trade-off using a thermodynamic free energy formulation: agents maximize expected utility (here the log-likelihood) minus an entropic cost. Hyland and Albarracín [4] include a direct KL cost on belief change, reflecting that large posterior shifts require high cognitive effort. Our model captures these ideas through a simple, interpretable log-odds update rule.

IV. COGNITIVE BIASES AS RATIONAL OUTCOMES

We now show that classical cognitive biases emerge naturally in our model by appropriate parameter choices or cost structures.

4.1. Conservatism

Conservatism refers to the empirical tendency to under-react to new evidence—i.e., the posterior moves less than Bayes’ rule would prescribe [12]. In our model, this corresponds to the case $0 < \lambda < 1$, where the evidence term $\ln(\text{BF})$ is down-weighted. The posterior log-odds shift is then $\lambda \cdot \ln(\text{BF})$ instead of $\ln(\text{BF})$, so the update is more modest. Psychologically, $\lambda < 1$ can be interpreted as the agent having limited attention or confidence in the reliability of the evidence signal, effectively discounting the new information.

4.2. Base-Rate Neglect

Base-rate neglect refers to underweighting the prior probability relative to evidence. In our framework, this can occur if λ is close to 1 (full weight on evidence) and μ is small (low cost penalty), so that the log-Bayes factor dominates the update. Equivalently, one may view it as effectively assigning a lower weight to the prior term. For example, if the evidence is presented in a context that emphasizes likelihood (a salient outcome-driven frame), individuals may behave as if λ is large. μ is negligible, yielding near-Bayesian emphasis on the likelihood term [2]. In the extreme case $\lambda = 1$, $\mu = 0$, the update is fully Bayesian and base rates enter only through Bayes’ rule; if agents disregard even the prior term entirely, one recovers the classical base-rate neglect scenario discussed by Kahneman and Tversky [11].

4.3. Confirmation Bias

Confirmation bias is the tendency to weigh evidence that supports prior beliefs more heavily while dismissing evidence that contradicts them. In our model, this can be represented by making the cost $C(B)$ asymmetrical: if updates that oppose the prior incur a higher cognitive cost than confirmatory updates, then $C(B)$ will be larger for disconfirming evidence. Essentially, the penalty $-\mu C(B)$ will tend to suppress belief updates that move away from the prior. This mechanism aligns with ideas in the literature that suggest agents prefer beliefs similar to their existing ones [4]. Therefore, confirmation bias can be viewed as a rational outcome of differing information costs arising from an asymmetric updating environment. In summary, our generalized rule offers a range of updating behaviors. By adjusting λ and μ , it bridges the gap between the prior and fully Bayesian updating, capturing various levels of under-reaction to evidence. Notably, Kopp [2] introduces a similar concept in cognitive tasks: he demonstrates that context (which can shift the relative emphasis on priors versus evidence) explains why conservatism appears in some tasks and why base-rate neglect occurs in others. Our model formalizes this trade-off by providing a clear interpretation of its parameters.

V. NUMERICAL ILLUSTRATION

To illustrate the quantitative effect of λ and μ , consider a simple medical diagnosis example. Suppose $P(A) = 0.05$ (a rare disease), $P(B | A) = 0.90$ (highly sensitive test), and $P(B | \neg A) = 0.10$ (false positive rate). Classical Bayes’ theorem yields:

$$P(A | B) = (0.90 \times 0.05) / (0.90 \times 0.05 + 0.10 \times 0.95) \approx 0.32.$$

That is, observing a positive test raises the probability of disease from 0.05 to 0.32. Now we apply the generalized update rule (2) with $C(B)$ taken as the KL-divergence from the prior. Table 1 shows the resulting posterior $P^*(A | B)$ for selected (λ, μ) parameter values.

Table 1. Posterior values $P^*(A|B)$ under the generalized update rule for the diagnostic example

λ (sensitivity)	μ (cost weight)	$P^*(A B)$ posterior	Interpretation
1.0	0.0	0.32	Classical Bayes’ rule
0.8	0.0	0.25	Mild conservatism
0.6	0.0	0.19	Moderate conservatism
0.6	0.2	0.16	Conservatism + information cost
0.4	0.0	0.13	Strong conservatism
0.4	0.3	0.10	Strong conservatism + high cost

These values are consistent with experiments on human judgment [1]. In particular, subjects often give posteriors in the range 0.15–0.20 for a similar scenario, reflecting conservatism. Our model with $\lambda < 1$ and $\mu > 0$ quantifies this. A more extensive numerical study (e.g., varying prior and likelihood ratios) would similarly show that the generalized update interpolates between the prior and Bayes’ rule as constraints tighten. Specifically, as $\lambda \rightarrow 0$, the posterior converges to the prior, and as $\lambda \rightarrow 1$, $\mu \rightarrow 0$, it converges to the Bayesian posterior.

VI. DISCUSSION

The proposed framework broadens the information-theoretic view of Bayesian inference by explicitly including cognitive constraints. Unlike purely normative models, our model predicts that belief updates will be lessened or biased in expected ways when information costs are not zero. This offers a rational explanation for biases usually seen as “irrational.” It also complements other bounded-rational models in existing research. For example, Ortega and Braun [3] develop a thermodynamic formalism for decision-making with information costs, and our rule is mathematically similar to their free-energy approach. The recent active inference literature also includes KL penalties on belief change [4]. Our model has practical implications for human-computer interaction and AI system design. In systems involving human input, understanding that people tend to undervalue evidence under cognitive load suggests how to present information effectively. For example, if an AI advisor recognizes that a user shows conservatism ($\lambda < 1$), it might present evidence more strongly or repeatedly to counteract the attenuation. Conversely, one could design decision-support systems that adjust probabilities to correct for

known biases. Our framework also relates to rational inattention theory [8], which models how agents optimally allocate limited attention. In future work, the parameters (λ , μ) could be fitted to behavioral data to enable precise predictions of individual performance across various decision tasks. Our analysis also points to directions for future research. Empirical studies could test whether human updating follows the one-parameter distortion we suggest by fitting λ and μ to individual data across a range of belief revision tasks. Theoretically, equation (2) could be derived from first principles, such as a constrained KL minimization with an expected cost similar to Shore and Johnson's maximum entropy axioms. Extensions to multi-hypothesis scenarios and iterative belief updating are also of great interest, as are dynamic information costs that evolve over time or with task difficulty.

VII. CONCLUSION

We have introduced a generalized Bayesian updating model that incorporates cognitive processing constraints via two interpretable parameters: a sensitivity parameter λ that scales the log-Bayes factor, and a cost weight μ that penalizes informational effort. The model recovers standard Bayes' rule when constraints vanish ($\lambda=1$, $\mu=0$), yet naturally produces conservative and biased updates under bounded rationality. This unifies normative and descriptive perspectives on belief revision: cognitive biases are re-interpreted as features of an optimized, resource-constrained architecture rather than mere errors.

The numerical illustration confirms that the model reproduces empirically observed posterior estimates in a medical diagnosis task. Future work can integrate this model into adaptive learning systems, explore its connections with active inference, and conduct empirical validation by fitting parameters to human behavioral data. We believe this generalized framework offers a productive bridge between the mathematical elegance of Bayesian statistics and the psychological reality of bounded-rational human cognition.

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Individual Motivations for Sustainable Consumption Practices among Malaysian Consumers

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Abstract. This paper aims to examine a set of individual factors that shape green purchase intentions. These factors include self efficacy, environmental attitudes, perceived severity, and gender. Data were collected through an online survey using a convenience sampling approach, which yielded a total of 373 usable responses. Structural equation modeling with PLS was employed to test the proposed hypotheses and to evaluate the relationships among the study variables. The results reveal that self efficacy, environmental attitudes, and perceived severity have meaningful and statistically significant relationships with green purchase behavior. These findings indicate that individuals who believe in their ability to make environmentally responsible choices, who hold positive attitudes toward environmental protection, and who perceive environmental issues as serious are more likely to engage in green purchasing. In contrast, gender shows no effect on the intention to buy green products, suggesting that the motivation to choose environmentally friendly goods is similar among male and female consumers. The overall findings align with previous research, reinforcing the idea that individual level psychological factors play an essential role in strengthening green purchase behavior. This study contributes additional evidence to the literature and highlights the importance of understanding personal motivations in promoting sustainable consumption. The paper concludes by offering practical recommendations for policymakers and practitioners. These recommendations include developing targeted awareness programs, strengthening environmental education, and designing communication strategies that enhance self efficacy and attitudes toward green consumption. Such efforts can support the creation of more effective green related policies and ultimately increase green purchase intentions within the community.

Index Terms: Green Purchase Intention, Self-Efficacy, Environmental Attitude, Perceived Severity, Gender

I. INTRODUCTION

Green purchases involve consumers procuring environmentally friendly products and initiatives aimed at conserving resources and protecting the natural environment. This encompasses various aspects such as primary materials, manufacturing, packaging, distribution, and disposal, emphasizing minimal adverse impacts on human health and the environment compared to alternatives (Zhang et al., 2024).

There has been a consistent increase in waste production over the years, paralleling economic and population growth. This trend is projected to continue, with Malaysia expected to dispose of 19 million tonnes of waste by 2050, compared to 14 million tonnes in 2021. Increased population growth exacerbates solid waste disposal challenges, primarily from household waste, which constitutes a significant portion of municipal solid waste (MSW) (Khazanah Research Institute, 2021).

Scholarly investigations focus on social determinants influencing environmentally sustainable purchasing, such

as product attributes, marketing, social norms, and social capital (Zhang et al., 2024). However, individual factors also play a crucial role, as evidenced by studies highlighting the influence of personal characteristics, attitudes, and intentions on green purchasing behavior (Chaihananchai & Anantachart (2023).

Consequently, this study aims to investigate the impact of perceived severity, self-efficacy, and environmental attitude, among other individual determinants, on the green purchasing intention of the Shah Alam community. Taken together, this research aims to address the following research questions:

RQ1. Do individual factors (self-efficacy, environmental attitude, perceived severity) influence consumers' green purchase behavior?

RQ2. Do individual factors (self-efficacy, environmental attitude, perceived severity) vary across the genders for consumers' green purchase behavior?

The following section outlines the research questions, followed by a review of the relevant literature, the

research methodology, and the analysis and presentation of findings. The paper concludes with a discussion of the results and the final conclusions

II. LITERATURE REVIEW AND HYPOTHESIS DEVELOPMENT

The phrase green purchase denotes the procurement of environmentally friendly products, which are commonly recycled (Mostofa, 2007). Furthermore, ecologically sustainable products serve to avert harm to both the natural world and society. Customer intentions and propensity to purchase green products are often considered in the evaluation of green purchasing behaviour; this, in turn, influences customer purchasing behaviour concerning ecologically sustainable products (Joshi & Rahman, 2015). More precisely, a sustainable or green product provides an abundance of benefits to society and the environment. Green products include, among other things, energy-efficient bulbs, eco-friendly containers, and recycled paper (Chaihanchai & Anantachart, 2023).

The Protection Motivation Theory (PMT) was developed by Rogers in 1975 in an effort to identify characteristics of risk-averse behaviour (Bockarjova & Steg, 2014). PMT successfully incorporates personal and social constructs to clarify the process of behavioural choice. According to Janmool (2017), the PMT functions on the premise that individuals participate in risk prevention actions as a result of their inherent motivation to protect themselves from potential hazards. The protection motivation theory investigates the coping strategies and decision-making processes of individuals who have experienced danger or turmoil in their lives. These choices are implemented as a preventive measure against perceived threats. The theory endeavours to predict and elucidate the reasons why individuals modify their future behaviour. According to Janmool (2017), the PMT assumes that individuals participate in risk-prevention activities as a result of their inherent motivation to protect themselves from potential dangers. This is due to the fact that ongoing utilisation of a deleterious product would necessitate individuals to contemplate the enduring environmental repercussions.

2.1 Self-efficacy and intention to make green purchases

Tabernero and Hernandez (2011) define self-efficacy as an individual's belief in their capacity to plan and execute behaviors effectively to address a specific situation in the future. It encompasses control over motivations, behaviors, and the social environment. Chaihanchai and Anantachart (2023) found that consumers with positive attitudes towards green products are more inclined to purchase them. Ahmed et al. (2023) revealed a significant link between individuals' environmental attitudes and their intentions to buy green products. This association is influenced by cognitive, motivational, affective, and selection processes. Bandura (1994) asserts that a strong sense of efficacy enhances achievement and well-being by framing difficult tasks as opportunities for growth rather than threats to be avoided.

According to the Protection Motivational Theory, individuals are driven to engage in risk prevention behaviors to safeguard themselves from potential hazards. Singh and Khanwani (2023) found a positive correlation between self-efficacy and intentions to purchase green products. Self-efficacy can predict attitudes and behaviors, aligning with the Protection Motivational Theory. Raharjo et al. (2023) also found a positive influence of self-efficacy on performance. It is noted that self-efficacy correlates with confidence in generating and selecting ideas.

H1: There is positive relationship between self-efficacy and the intention to green purchases.

2.2 Environmental Attitude and Intention to Make Green Purchases

Attitude is a dual-natured subjective sentiment, encompassing both positive and negative dimensions. It is constructed as a result of an individual's execution of a particular behaviour (Ajzen, 1991). The term "it" pertains to a cognitive assessment utilised to quantify the importance attributed to environmental protection in the context of attitudes towards the environment. According to Ajzen (1991), there exists a positive correlation between an individual's attitude and behavioural intentions. In contrast, attitudes that are negative in nature are correlated with intentions that are more negative in nature. Positive attitudes and the green values associated with a product have a substantial impact on consumer's intention to purchase that product (Chaihanchai & Anantachart, 2023; Ahmed et al., 2022).

Individuals who have been exposed to a greater quantity of media exhibit greater enthusiasm and participate in a greater number of environmental protection activities, according to the findings of Ahmed et al. (2022). It becomes evident upon closer investigation that the underlying mechanism is the diffusion of ambient information. Furthermore, our results remain unaffected by a wide array of robustness evaluations. The influence of media exposure at individual-level on pro-environmental attitudes can be seen through the use of instrumental variable estimates. In order to encourage environmentally conscious attitudes and actions in developing nations, communication efforts must revolve around the capacity of media to disseminate environmental knowledge and contribute to the development of a more sustainable society. The following hypothesis was thus proposed as the foundation for the research:

H2: There is positive relationship between individuals' environmental attitude and green purchase intention.

2.3 Perceived Severity and Intention to Purchase Green

Perceived severity can be defined as the extent to which an individual recognizes the potential danger posed by a nearby object or situation (Janmool, 2017). It is instrumental in predicting behavior change or intentions to change, as individuals are unlikely to initiate change until they perceive a significant impact (Kashi, 2020). This concept becomes particularly relevant in the context

of green consumerism, where the consciousness of returning to nature influences green purchase intentions.

Hassan et al. (2023) investigated the relationship between perceived severity, satisfaction with government response, and behavioral modifications during crises. They found that individuals with higher anxiety levels and a stronger perception of severity were more likely to adopt protective behaviors. Conversely, those with an optimism bias or a positive view of government response exhibited fewer behavioral changes. It shows the importance of understanding psychological factors influencing individual behavior in response to crises.

Overall, perceived severity plays a crucial role in shaping behavior and intention to purchase green products, as individuals are more likely to change behavior when they perceive a significant threat.

H3: There is a positive relationship between the intention to purchase green products and the perceived severity.

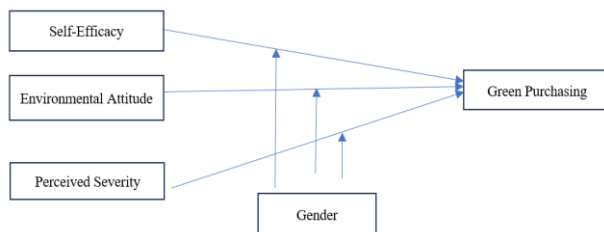


Figure 1: Conceptual Framework

2.4 Moderating effect of gender

Gender significantly influences individuals' purchasing decisions (Hur et al., 2014; Channa et al., 2020). Hur et al. (2014) examined the moderating effect of gender on the relationship between consumer attitude, perceived utility, and ease of use, revealing gender's role as a moderator in these relationships. Channa et al. (2022) found that females tend to have stronger environmental concerns and preferences for eco-friendly products compared to males. Similarly, Gilal et al. (2020) discovered that women exhibit greater environmental responsibility and commitment to environmental protection. Gilal et al. (2020) hypothesized that female consumers are more likely than males to choose environmentally friendly products, given women's dominance in household purchasing decisions.

Based on these findings and grounded in the gender schema theory (GST), the hypothesis proposes that environmental variables will have a more significant predictive influence on females' purchasing of eco-friendly products compared to males. Thus, gender intricacies are pivotal in shaping consumer behavior, particularly in the preference for environmentally conscious products like athletic wear.

H4a. Female consumers in Malaysia are anticipated to demonstrate higher levels of self efficacy than male consumers in relation to green purchase behaviour.

H4b. Female consumers in Malaysia are assumed to express more environmental attitudes than male consumers in Malaysia to demonstrate green purchase behavior.

H4c. Female consumers in Malaysia are more perceived severity than male consumers to purchase eco-friendly products.

III. METHODOLOGY

The research employed a quantitative approach to investigate environmentally conscious consumer behavior in Malaysia, utilizing a convenience sample of 373 participants. Measurement items were adapted from prior studies, including four items from Shafiei & Maleksaeidi (2020) for self-efficacy, five items from Silva and Lopez, (2015) for environmental attitude, three items from Shafiei & Maleksaeidi (2020) for perceived severity, and four items from Maichum et al. (2016) for green purchase intention, all measured on a five-point Likert scale.

Data collection was facilitated through a survey distributed online via Google Forms on Facebook, resulting in 373 usable responses. Sample size considerations were based on guidelines from Hair et al. (2021), Gefen et al. (2011), ensuring adequacy for analysis. To address common method variance, participants were briefed on the study's objectives, anonymity, and the lack of right or wrong answers. Multicollinearity was assessed using Variance Inflated Factor (VIF), with values for self-efficacy, environmental attitude, and perceived severity meeting acceptable thresholds (Hair et al., 2021). Overall, meticulous methodology ensured robust data collection and analysis in exploring environmentally conscious consumer behavior in Malaysia.

3.1 Statistical procedures

The Partial least square structural equation modeling (PLS-SEM) technique was applied to analyze the data, using SmartPLS software version 4. Prediction is the focus of the current analysis. Hence, PLS-SEM is deemed suitable and feasible due to its capacity to concurrently estimate postulated relationships, as demonstrated in structural models (Hair et al., 2021; Henseler et al., 2015). Moreover, the selection of a suitable analysis technique is contingent upon the nature of latent variables in the path model that scholars aim to estimate. The literature suggests that when estimating common factor models, Covariance-based Structural Equation Modelling (CB-SEM) is the appropriate method to use. PLS-SEM is more suitable due to the composite nature of our model, which is characterised by variables that are theoretical in nature and have been developed through research (Henseler, 2017).

IV. RESULTS

4.1 Demographic Profile

In terms of gender distribution within this study, there were 160 male respondents (42.9%) and 213 female respondents (57.1%). Regarding age categories, respondents were classified into five groups: 21-25, 26-30, 31-35, 36-40, and 41 years and above. The highest number of respondents are within the age range of 21-25 years, comprising 255 respondents (72%). Following this, the 26-30 age group had 39 respondents (11%), followed

by the 31-35 age group with 22 respondents (6.2%). The age group of 41 years and above had 23 respondents (6.5%), and the lowest number of respondents belonged to the 36-40 age group, consisting of only 15 respondents (4.2%).

4.2 Measurement Model

In line with recommendations in the PLS SEM literature, a two step approach was adopted (Anderson and Gerbing, 1988). Initially, an assessment of the measurement model was conducted by examining the inter-item reliability, convergent validity, and internal consistency reliability of eco-friendly athletic wear (Hair et al., 2021; Henseler et al., 2017). The determination of inter-item reliability was conducted through the analysis of factor loadings between items, with a cutoff value of 0.70 (Hair et al., 2021). To ascertain convergent validity, the average variance extracted (AVE) was evaluated; it was observed that all

values exceeded the 0.50 threshold, as established by Gefen et al. (2000). In a similar vein, the assessment of internal consistency reliability involved the examination of composite reliability values, with a fixed threshold of 0.70 (Hair et al., 2021; Gefen et al., 2000). The comprehensive findings of the measurement model are displayed in Table 1.

In order to identify discriminant validity, the Heterotrait-monotrait ratio of correlations (HTMT) was utilised. The discriminant validity is ascertained using this method following the multi-trait-multimethod matrix (Henseler et al., 2017). According to the literature, to establish discriminant validity, the HTMT threshold values must be below 0.85 (Kline, 2011). Discriminant validity has been established, according to the HTMT values shown in Table 1, by adhering to the 0.85 threshold proposed by Kline (2011).

Table 1: Measurement Model

Constructs		Loadings	Cronbach's Alpha	Composite Reliability	Average Variance Extracted
Self-Efficacy	SE1	0.768	0.764	0.746	0.515
	SE2	0.872			
	SE3	0.814			
	SE4	0.763			
Environmental Attitude	EA1	0.787	0.888	0.920	0.506
	EA2	0.825			
	EA3	0.852			
	EA4	0.832			
	EA5	0.764			
Perceive Severity	PS1	0.846	0.835	0.816	0.690
	PS2	0.801			
	PS3	0.725			
Green Purchase Intention	GPI1	0.840	0.830	0.804	0.523
	GPI2	0.752			
	GPI3	0.712			
	GPI4	0.712			

4.3 Structural model

In accordance with established guidelines, the second step involved assessing the structural model (Hair et al., 2021; Anderson and Gerbing, 1988). The significance of the path coefficients was evaluated using a bootstrapping

procedure with 5,000 subsamples in Smart PLS 3.3.3. The structural model results, as presented in Tables 2 and 3, indicate that hypotheses 1, 2, and 3 are fully supported, whereas hypotheses 4a, 4b, and 4c are not supported by the data.

Table 2: Hypothesis testing

Relationships	Standardized Beta	S.E.	t-value	BCI LL	BCI UL	f^2	Q ²	VIF	Decision
Self-Efficacy - Green Purchase Intention	0.750	0.050	4.025	0.056	0.276	0.128	1.265	1.028	Supported
Environmental Attitude - Green Purchase Intention	0.702	0.056	4.142	0.136	0.317	0.090	0.501	1.226	Supported
Perceive Severity - Green Purchase Intention	0.620	0.054	2.051	0.066	0.466	0.167	0.196	1.846	Supported

This study employed bootstrapping with 5,000 resamples using the PLS-SEM technique, the structural model was evaluated to look at the importance of the associations that were hypothesised and shown in Table 3 details the results of path coefficients (β), standard errors, t -values, effect

size (f^2), predictive relevance (Q^2), and variance inflation factors (VIFs). As all VIF values are below the threshold of 5.00, the structural model has no problems with the latent variable collinearity of the present study, and consequently, an evaluation of the remaining tests was

conducted. Specifically, self-efficacy had a positive impact on Green Purchase Intention ($\beta_1 = 0.227$, bootstrap t -value = 4.153, $p < 0.05$); thus, H1 was supported. Next, support was also resilient for H2, confirming that Green Purchase Intention was positively influenced by Environmental Attitude ($\beta_2 = 0.169$, bootstrap t -value = 3.023 $p < 0.05$). For H3, the results of $\beta_3 = 0.264$ with bootstrap t -value = 2.056 at $p < 0.05$, reflecting the linkages between Perceive Severity and Green Purchase Intention is positive. Henceforth, H3 was also reinforced.

Subsequent analysis was done on the effect size (f^2) of exogenous latent constructs on endogenous latent constructs. According to Cohen's (1988) guidelines, a f^2 value of 0.35 denotes a significant influence, 0.15 is a moderate effect, and 0.02 is a small effect. Table 3 shows that there was a small correlation between Self-Efficacy and Green Purchase Intention ($f^2 = 0.080$). Similarly, Environmental Attitude had a small impact on Green Purchase Intention ($f^2 = 0.017$). On the other hand, the

relationships between perceived severity and Green Purchase Intention ($f^2 = 0.156$) exhibited a moderate effect size. Ensuring that the blindfolding procedure was used to determine the research model's predictive relevance (Q^2). Hair *et al.* (2017) noted that the model's predictive relevance requires a value of Q^2 greater than 0. The Q^2 values for this study ranged from 0.120 to 0.258, indicating that the model was sufficiently predictive. Therefore, the above-mentioned three direct effects demonstrated moderate predictive relevance.

4.4 Examining the Moderation Effect of Gender

In order to analyse gender as the moderation factor, multi-group analysis in SmartPLS 4.0 was performed. The two groups comprised of Male ($N = 160$) and Female ($N = 213$). SRMR score for both of the groups, is found to be less than 0.09, which indicates a good fit. Although the path coefficients varied but the deviation is not significant (as shown in Table 3). Therefore, hypothesis H4 (a),(b) and (c) are not supported.

Table 3: Moderation effect of gender

Relationship	Path Coefficients (Female, N-213)	Path Coefficients (Male, N-160)	Path Coefficients- difference (Female-Male)	p-Value (Female vs Male)
Self efficacy - > Green Purchase intention	0.423	0.521	0.098	0.344
Environmental attitude - > Green Purchase intention	0.194	0.235	0.041	0.622
Perceived Severity - > Green Purchase intention	0.232	0.097	0.136	0.099

V. DISCUSSIONS

The research examines the influence of perceived severity, self-efficacy, and environmental attitude on green purchasing behavior, with gender as a moderating variable. Drawing from gender schema theory and Protection Motivational Theory (PMT), the study aims to deepen understanding of environmentally conscious consumer behavior.

Significant correlations were found between self-efficacy and green purchasing behavior, indicating that individuals recognizing environmental fragility are motivated to choose eco-friendly products for sustainability, consistent with Ahmed *et al.* (2023), Tawde *et al.* (2023) and Tiwari (2023).

Perceived severity positively influences sustainable decision-making, corroborating findings by Moslehpour *et al.* (2023) and Fahmi *et al.* (2023), indicating that heightened environmental concerns drive green purchasing intentions.

Unexpectedly, no significant gender disparities were found in green purchasing intention, contradicting previous studies suggesting differing perspectives on green purchases (Gumparthy & Srivastava, 2024; Leong *et al.*, 2024). This indicates that gender may not moderate the relationship between the studied factors and green purchasing behavior.

Overall, the study underscores the importance of understanding social perceptions in influencing green purchasing behavior, offering insights for practitioners to leverage opinion leaders to promote environmentally friendly products.

VI. THEORETICAL AND MANAGERIAL IMPLICATIONS

The research contributes to both practical and academic understanding of consumption values and their impact on green purchasing intention, particularly in Malaysia. Constructs such as self-efficacy, environmental attitude, and perceived severity significantly influence customers' intentions to purchase green products. These findings provide insights for emerging economies like China, India, and Vietnam, where environmental awareness is growing due to substantial populations and ecological imperatives.

A limitation is acknowledged regarding the sample primarily consisting of young, educated Malaysians, affecting generalizability to other global or Asian contexts. However, academically, the study enhances understanding of a significant South Asian economy, offering a conceptual framework for future research in the Asia-Pacific region.

The research highlights the relationship between self-efficacy, environmental attitude, and perceived severity, emphasizing the adaptability of established instruments and research models in the global context. The findings

are valuable for academics, businesses, and policymakers, informing green marketing strategies not only in Malaysia but also in other Asian countries.

Practically, organizations are encouraged to incorporate functional, emotional, and social values into their offerings, along with engaging campaigns to promote environmental awareness and green purchasing behavior. There's a call for global initiatives, emphasizing companies' role in promoting eco-friendly behavior to preserve natural resources. The study advocates for ongoing efforts by governments and organizations to prioritize environmental sustainability, fostering green consumption to elevate public awareness and emotional involvement. It emphasizes the collaborative role of academia and industry in shaping a sustainable future.

VII. CONCLUSION

This study applied Protection Motivation Theory (PMT) and Gender Schema Theory (GST) to explore how environmental motivational factors influence consumers' intentions to purchase eco-friendly products, with gender as a moderating variable. Through empirical analysis, it was found that factors such as self-efficacy, environmental attitude, and perceived severity positively impact consumers' intentions to engage in environmentally responsible purchasing behavior. However, gender was not found to moderate this relationship.

The research presents an innovative approach to promoting environmentally responsible consumer behavior by examining the influence of motivational factors and gender. It aims to contribute to ongoing discussions on mitigating negative environmental impacts of consumerism and provides practical insights for fostering more sustainable consumer choices.

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Graduate Students' Satisfaction on the Implementation of the Services Offered by the Office of Student's Affairs of BASC

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Abstract. In the context Bulacan Agricultural State College's (BASC) new mandate to transition into a university under Republic Act 11783, it is imperative to assess and evaluate the implementation of frontline services for graduate students to identify areas for enhancement and further address student welfare. The ongoing enhancement of services is essential for achieving and sustaining quality, prompting researchers to examine the degree of implementation, student satisfaction levels, and preferences about the services provided by the Office of Student Affairs and Services. Student satisfaction measurement is considered a strategic issue for educational institutions because satisfaction is similar to profit-and-loss accounting in business organizations. If satisfaction is high, then the university is making sizeable profits as a result of having provided students with knowledge, skills, and targeted abilities. The student will be contented with their academic achievement and their university life and will speak positively about the college because satisfaction is the ultimate goal of everyone. The respondents of the study were graduate students enrolled in the graduate programs, 68 female and 37 male students from the Colleges of Agriculture and of Education Graduates Studies. The majority of the respondents are enrolled in the Master of Arts in Education, major in Educational Management and the least are the students enrolled in the Master of Arts in Education, major in Mathematics. The study used the descriptive research design using a survey questionnaire. It was realized that most of the respondents observed that "student discipline" under Student Development was very highly implemented and they are very highly satisfied with "student development". Although the respondents rated almost all the parameters as very highly implemented and very highly satisfied, the respondents suggested the earlier issuance of the student handbook, increasing students' involvement in the development and revision of the student handbook, hiring of additional personnel that will assist during enrolment, information dissemination must be ahead of time, more good project/programs for the students that will develop them holistically and improve health services.

Index Terms: Satisfaction, Student Services, Program Implementation, Student Affairs

I. INTRODUCTION

The Office of Student Affairs and Services (OSAS) is a student supplemental service unit of an educational institution that is under the supervision of the Office of the Vice President for Academic Affairs (VPAA). The services of the OSAS cater to both undergraduate and graduate students of the college or university. They serve as aid on both levels in addressing their needs for professional growth, emotional, mental and psychological well-being.

However, student affairs usually focus on the needs and development of undergraduate students. Moreover, many student affairs professionals serve and support graduate and professional students a number of needs and concerns that differ from those of the undergraduate level. The struggle of a graduate student may include the impostor syndrome or having a hard time believing they have attained success, having the sense of belongingness,

isolation and time management. The OSAS may help the graduate students in overcoming these struggles.

As the office that handles both the undergraduate and the graduate scholars of an educational institution, quality services and maximized executions of programs should be upheld. A similar study conducted [1] have shown that a positive influence of service quality on student satisfaction and a positive influence of student satisfaction leads to student loyalty. Every educational institutions aims to have an increase of enrollees and retention of current students in order to sustain operations. Student satisfaction measurement is considered a strategic issue for educational institutions because satisfaction is similar to profit-and-loss accounting in business organizations. If satisfaction is high, then the university is making sizeable profits as a result of having provided students with knowledge, skills and targeted abilities. Student will be pleased with their academic achievement and their university life and will speak positively about the college

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because satisfaction is the ultimate goal, and the ultimate goal is a reflection of high levels of service quality [2].

Assessment and monitoring of the implementation of the programs for graduate students is essential in order for the school to know where to improve more and what to address further regarding the welfare of the graduate students [3]. Inadequacy of assessment will lead to no improvement of services and worse, to decrease in students. Furthermore, assessing the implementation of programs and services may start additional services of the OSAS among graduated students as an enhancement of the existing ones [4]. Leading to a more holistic graduate studies program. Though they are expected to be matured members of the society, it is still beneficial among graduate students to have the school's support for their well-being. Most of them do multiple roles in life like being a student and at the same time maintaining a job. Running a life of multiple responsibilities can be stressful so it would be good that they know that they can get aid from the Office of the Students' Affairs on dealing with certain graduate students' struggles.

In the Philippines, it is mandated by the Commission on Higher Education (CHED) Memorandum Order Number 9, series of 2013, that the Student Affairs and Services of higher education institutions must provide and continuously improve the quality of service it provides in order to aid in attaining the holistic development of students. In order to do this, certain measures in assessing the service quality of this significant office in the college must take place. Since development and improvement of services is impelled, this has propelled the researchers to conduct an assessment to the level of implementation and satisfaction of the graduate student on the programs and services of BASC-OSAS. This may aid to attaining the standards of services expected from a student affairs office by not only CHED but all the students of the College.

The study aimed to assess the satisfaction of the graduate students on the implementation of the programs and services of the BASC Students Affairs Office. Specifically, the researchers accomplished the following objectives:

- (1) describe the demographic profile of the graduate students in terms of sex, program, and major;
- (2) identify the perceptions of the graduate students on the extent of implementation of the services offered by the office in terms of the following:
 - 2.1. Student Welfare including the following
 - a. Information and Orientation Services;
 - b. Guidance and Counseling Services; and
 - c. Student Handbook Development.
 - 2.2. Student Development including the following:
 - a. Student Activities;
 - b. Student Organization and Activities;
 - c. Student Council/ Government;
 - d. Student Discipline; and
 - e. Student Publication.

- (3) determine the level of students' satisfaction on the quality of student services in the following areas:

- 3.1. Student Welfare
- 3.2. Student Development
- 3.3. Institutional Programs and Services

- (4) determine the common issues and problems encountered by the graduate students during their stay in BASC.

II. METHODOLOGY

The researchers employed a quantitative research design to evaluate the different Student Affairs Services (SAS) units, their roles, and responsibilities for School Year 2018 to 2022. The assessment was conducted using a survey instrument administered to 20% of the graduate student population enrolled in all graduate studies programs. For the qualitative component, interviews were conducted with selected students to identify common issues and challenges encountered by graduate students. The survey instrument and interview questionnaires used in this study were both locally developed. The survey included Likert scale questions with five response categories shown in Table 1.

Table 1. Five-Point Likert Scale

Weighted Mean	Verbal description-implementation and level of satisfaction
4.21 – 5.0	Very Highly Implemented (VHI) and Very Highly Satisfied (VHS)
3.41 – 4.20	Highly Implemented (HI) and Highly Satisfied (HS)
2.61 – 3.40	Moderately Implemented (MI) and Moderately Satisfied (MS)
1.81 – 2.60	Slightly Implemented (SI) and Slightly Satisfied (SS)
1.00 – 1.80	Not Implemented (NI) and Not Satisfied (NS)

The survey questionnaire was developed based on Commission on Higher Education (CHED) Memorandum Order (CMO) No. 9, s. 2013, which outlines policies, standards, and guidelines for graduate education. To enhance its empirical validity, the instrument adapted components from established empirical studies [5], specifically incorporating their validated application of the Likert scale for measuring perception and satisfaction. The researcher adjusted the questionnaire's satisfaction characteristics to better meet the particular goals of this investigation while staying true to the primary ideas of the two original publications.

The survey's data will provide an empirical basis for the ongoing standardization and enhancement of the quality of Student Academic Services (SAS) offered to graduate students. This program seeks to improve the overall academic experience for enrolled graduate students by guaranteeing that the SAS offerings continuously comply with the guidelines established by CHED. In order to minimize selection bias and guarantee that every eligible student had an equal chance of being included, the participants were chosen using a straightforward random

sampling procedure. All enrolled graduate students for the 2022– 2023 academic year made up the study's target population.

In order to increase reach and take participant preferences into account, a hybrid approach was used for the data collection and procedures, using both printed questionnaires and online questions via Google Forms. The researchers worked closely with the program chairs of each academic institution to ensure a systematic and effective dissemination process. A descriptive quantitative research design was used in the study. Descriptive statistics were used to analyze the data; in particular, the mean and standard deviation were computed to summarize the responses' central tendency and dispersion. Additionally, the prevalence and distribution of different response types were interpreted using frequency distributions and percentages.

III. RESULTS AND DISCUSSIONS

A. Objective 1 – Demographic Profile of the Graduate Students

A total of 125 students responded to the survey questionnaire administered by the researchers both online and face-to-face. Of these, 65.60% were female, while 34.40% were male, as shown in Table 2 below.

Table 2. Respondents Sex, Program and Major

	Number of Respondents	Percentage
Sex		
Females	82	65.60%
Males	43	34.40%
Total	125	100.00%
Program		
PhD Developmental Education	34	27.20%
PhD Agricultural Sciences major in Horticulture	1	0.80%
MAED Educational Management	68	54.40%
MAED Science	8	6.40%
MAED Mathematics	3	2.40%
MSA Agricultural Extension	8	6.40%
MSA Horticulture	1	0.80%
MSA Animal Science	2	1.60%
Total	125	100.00%

Majority of the respondents were enrolled in the College of Education Graduate Studies. As shown in the table above, 54.40% were from Master of Arts in Education major in Educational Management, and 27.20% were from Doctor of Philosophy in Developmental Education, while 8.80% of the respondents came from Master of Science in Agriculture, and only 0.80% of the respondents came from Doctor of Philosophy in Agricultural Science major in Horticulture. This can be attributed also to the total enrolled graduate students were accounted to the College of Education Graduate Studies.

B. Objective 2 – Perceptions of the Graduate Students on the Extent of Implementation of the services offered

Table 3 presented the perceptions of the graduate students on the level of extent of implementations of the services offered by OSAS. the comprehensive evaluation of student welfare programs and services yielded an overall mean of 4.39, which corresponds to a verbal description of "very highly implemented." A detailed examination of individual items revealed that "information and orientation services" received the highest weighted mean of 4.47, signifying its exceptional implementation. Conversely, "student handbook development" registered the lowest weighted mean at 4.30. Notably, despite this minor disparity, both aforementioned items were characterized as "very highly implemented," indicating a consistently high level of execution across key service areas.

Table 3. Graduate Students Perceptions on Welfare Programs and Services

STUDENT WELFARE	Weighted Mean	Verbal Description
Information and Orientation Services	4.47	VHI
Guidance and Counseling Services	4.40	VHI
Student Handbook Development	4.30	VHI
Overall Mean	4.39	VHI

These results underscore that the Office of Student Affairs and Services (SAS) information and orientation services are, in fact, well-executed from the viewpoint of the students. The college's continuous implementation of thorough orientation programs, which are vitally responsive to the changing demands of its student body, is a noteworthy element that has contributed to its excellent rating. Existing literature [6] supports the significance of these orientations, even for graduate students, and highlights how important they are for promoting peer interaction, making the transition to graduate school easier, building campus familiarity, encouraging comfortable interaction with faculty and administration, and improving interpersonal understanding and self-awareness. Intimate small-group settings and a variety of programming possibilities efficiently channel these many advantages to students.

Furthermore, these findings are congruent with prior research [7], similarly reported "very satisfactory" ratings for information and orientation services. This parallel finding reinforces the notion that students highly value regularly scheduled orientations at the academic year's outset, alongside specialized orientation initiatives for transferees and returning students, services supporting college life adjustment, the provision of current and organized information, and the accessibility of educational, career-related, and social information pertinent to their needs.

The comprehensive evaluation of student development programs and services, as detailed in Table 4, yielded an overall mean of 4.50, which is interpreted as "Very Highly Implemented." This high mean score collectively indicates that the institution's efforts in fostering student development are perceived by the student body as exceptionally robust and effective. A granular analysis of the individual components revealed that Student Discipline achieved the highest weighted mean of 4.52, signifying its paramount implementation effectiveness. Conversely, Student Publication registered the lowest weighted mean among the four evaluated items, with a value of 4.48. Notwithstanding this marginal difference, all assessed student development programs and services consistently fall within the "Very Highly Implemented" category, underscoring a pervasive excellence in their execution.

Table 4. Graduate Students Perceptions on Development Programs and Services

Student Development	Weighted Mean	Verbal Description
Student Organization and Activities	4.49	VHI
Student Council/ Government	4.50	VHI
Student Discipline	4.52	VHI
Student Publication	4.48	VHI
Overall Mean	4.50	VHI

These results strongly imply that the Office of Student Affairs and Services (OSAS) successfully implements the rules set forth by the institution regarding student behavior, especially when it comes to student discipline. The pedagogical necessity of preserving a neat and comfortable learning environment is in line with the apparent high degree of student discipline implementation. Teamwork among all institutional stakeholders and consistency in the application of policies are the cornerstones of effective disciplinary practices [8]. Regular examination of established discipline rules and ongoing assessment of techniques for reducing school disruptions are considered crucial for maintaining efficacy and responsiveness to the changing requirements of the student body.

Furthermore, the robust implementation of discipline campus suggests that school and administrative personnel have effectively developed and implemented methods for controlling student behavior. This is crucial since disciplinary problems can seriously hinder learning by causing distractions, which emphasizes [9] how well-managed discipline has a favorable impact on learning results. In graduate school, it has been noted that students gradually improve their ability to control their own behavior through regular exposure to and observance of disciplinary frameworks. This reduces disruptions in the classroom and helps to create a more favorable and effective learning environment. These services' continuously high ratings attest to their vital significance in graduate students' academic achievement and overall development.

C. Objective 3 - Level of Graduate Students' Satisfaction on the Quality of Student Services

The aggregate and disaggregated levels of student satisfaction across key program and service categories where presented in Table 5. The overall mean satisfaction score for all evaluated items is 4.41, which, consistent with the Likert scale interpretation, signifies a "Very Highly Satisfied" perception among graduate students. This overarching result indicates a strong positive reception of the comprehensive support and developmental opportunities provided by the institution.

Table 5. Graduate Students Level of Satisfaction on the Quality of Student Services

Student Satisfaction Indicators	Weighted Mean	Verbal Description
Student Welfare Program and Services	4.43	VHS
Student Development Programs and Services	4.44	VHS
Institutional Student Programs and Services	4.37	VHS
Overall Mean	4.41	VHS

A closer examination of the data reveals distinct satisfaction profiles across the three categories. With the highest weighted mean of 4.44, Student Development Programs and Services emerged as the main factor influencing graduate student satisfaction. At 4.37, Institutional Student Programs and Services, on the other hand, had the lowest weighted mean. However, it is important to remember that in spite of this apparent discrepancy, all three categories, including Student Welfare Programs and Services—consistently received a "Very Highly Satisfied" answer, indicating a consistently high degree of satisfaction with the services provided.

The high level of satisfaction with student development programs and services is particularly significant, as these programs are instrumental in providing opportunities for leadership development among graduate students. The critical role of such programs is emphasized in a similar study [10], in cultivating essential leadership competencies. The institution's accomplishments in this area point to the successful planning and execution of programs meant to improve these abilities. The wealth of research on the effect of leadership on student outcomes supports this conclusion even more. According to research, leadership has the second-highest impact on student learning [11], behind direct classroom instruction, in terms of influencing student achievement.

The pronounced impact of leadership is particularly evident in educational contexts serving students with higher needs, underscoring the vital role these development programs play in equipping graduate students for future professional and societal contributions [12]. The consistent "Very Highly Satisfied" rating across these programs suggests that BASC (or the institution under study) is effectively meeting a crucial developmental need of its graduate student population [13], thereby fostering capabilities that are broadly

recognized as pivotal for success beyond academic pursuits.

D. Objective 4 – Common Issues and Problems Encountered

In addition to quantitative satisfaction indicators, qualitative information obtained from graduate student interviews reveals subtleties in their opinions of institutional services. The most common qualitative response for services that needed improvement was "none," which can be taken as an implied indication that the Office of Student Affairs and Services (OSAS) provided generally satisfactory services even if it is not a direct indicator of satisfaction. This shows that essential services mostly fulfill or surpass students' initial expectations.

A small percentage of respondents did, however, identify specific areas that needed improvement, with the majority concentrating on how quickly complaints and concerns were addressed. This emphasizes how urgently OSAS needs to improve its communication and resolution processes, answers to complaints and questions from students, as well as proving that the institution is responsive, since delays can exacerbate annoyance and lower the sense of service quality. In a similar vein, some recommendations

[14] highlighted the need for better support with admissions and enrollment processes, pointing to possible areas of complication during these crucial student transitioning periods. Additionally, suggestions for more graduate-level promotional materials point to a calculated chance to raise Graduate School's profile and attractiveness in the community at large [13,15], which might draw in a larger number of potential students.

In terms of services not currently offered but desired, the most frequently articulated need was for the creation and conduct of more seminars specifically tailored for graduate students. Graduate seminars play a pivotal role in immersing students in their discipline, fostering critical thinking, developing research skills, and enhancing presentation abilities [16]. Providing more specialized and relevant seminars could significantly augment graduate students' academic and professional development beyond their core coursework. Concurrently, a common request for faster internet access on campus underscores the increasing reliance of graduate students on robust digital infrastructure for research, online learning components, and general academic activities, reflecting a broader expectation of seamless technological integration in higher education environments.

Conversely, the service most highly praised by respondents, and one that significantly eased their academic lives at BASC, was the hybrid learning modality. The overwhelming preference for this mode of delivery was attributed to its inherent convenience for a demographic often balancing academic pursuits with professional employment. This finding aligns with literature on hybrid learning, which consistently identifies its flexibility as a major benefit for graduate students juggling work and personal commitments, reducing commuting time and offering asynchronous learning

options. The ability to conduct classes online and only attend campus for essential functions like examinations, critical face-to-face interaction, optimizes their time management and accessibility.

The qualitative data also identified recurring challenges. The primary issues encountered by graduate students were the speed of response to their concerns and the availability and quality of internet access during campus visits. These points reiterate the earlier suggestions for improvement, solidifying them as key priorities for OSAS. Moreover, a salient suggestion emerged for the increased promotion and provision of health and wellness programs specifically for graduate students. This reflects a growing recognition of the unique stressors faced by this population and the importance of holistic well-being support to ensure their academic success and overall quality of life [17]. Addressing these identified service gaps and enhancing current provisions would directly contribute to an even more supportive and effective environment for BASC's graduate student community.

IV. CONCLUSION

The demographics of enrolled graduate students as well as their opinions of different student services and programs were examined in this study. According to the demographic information, the majority of graduate students were female and enrolled in the Institute of Education Graduate Studies' MAEd in Educational Management and PhD in Developmental Education programs.

The findings reveal a consistently high perception of service implementation. Student Welfare Programs and Services were rated as "Very Highly Implemented," with "Information and Orientation Services" receiving the highest specific rating, underscoring their perceived effectiveness. Similarly, Student Development Programs and Services were also categorized as "Very Highly Implemented," with "Student Discipline" identified as the most effectively implemented aspect within this category. Collectively, these results demonstrate that BASC graduate students perceive the BASC-Office of Student Affairs and Services (OSAS) as highly effective in implementing its services.

Regarding student satisfaction, graduate students reported being "Very Highly Satisfied" across all evaluated indicators. Among these, Student Development Programs and Services garnered the highest satisfaction rating, particularly in the area of leadership development. This high level of satisfaction suggests that BASC successfully supports its graduate students in cultivating crucial leadership skills, which are vital for their professional growth and career advancement post-graduation.

V. RECOMMENDATIONS

The research identifies key recommendations and areas for improvement to further strengthen the services provided by the Office of Student Affairs and Services (OSAS) to graduate students. These recommendations aim to build upon current strengths and address identified opportunities for enhancement.

A primary recommendation is to prioritize the promotion of health and wellness among graduate students. This can be effectively addressed by organizing more in-person activities that foster interaction. Implementing such activities on a monthly basis could significantly enhance camaraderie, cultivate a stronger sense of community, and create a healthy competitive environment. This, in turn, is expected to motivate students to excel academically and successfully complete their graduate studies by providing crucial social and emotional support networks.

Another crucial recommendation is the re-establishment of the graduate student council and the empowerment of its members to assume a more active and influential role in peer support. Given that leadership emerged as the most highly developed skill among BASC graduate students, the revitalized student council can strategically function as "leaders among leaders." This council would be uniquely positioned to guide and assist their fellow students across both academic and extracurricular domains. Strengthening student leadership through this initiative is anticipated to further enhance overall student engagement, foster greater collaboration, and significantly improve the comprehensive student experience within the graduate school.

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Polya's Effect on Improving 9th Graders' Ability to Solve Non-Routine Math Problems - A Quasi-Experimental Study in Lebanese Private Schools

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Abstract. This quasi-experimental study focused on the role of Polya's four-steps in mitigating the problem-solving difficulties that ninth graders studying in private schools in Lebanon faced when solving non-routine math problems (NRMPs). A quantitative approach was used to examine the effectiveness of Polya's four-step framework: understanding the problem, devising a plan, carrying out the plan, and looking back the solution. The research sample consisted of 67 students, aged 14-15-year-old, who were given Polya-based instruction as 2-week intervention. Pre-post- tests were administered to measure significant improvements in students' problem-solving abilities. Findings indicated that Polya's structured approach significantly enhanced the experimental group's cognitive skills and reduced their difficulties with solving NRMPs. The results suggested that integrating Polya's steps into the mathematics problem-solving could promote deeper understanding of mathematical concepts and improve 9th graders problem-solving competence. This research added to knowledge on effective strategies for mathematics instruction, focusing on the importance of structured approaches which enabled students to handle NRMPs.

Index Terms: Polya's Approach – Non-Routine Math Problems (NRMPs) – Bodin's Taxonomy – Cognitive Development

I. INTRODUCTION AND PROBLEMATIC

The question of mathematics education had always been one of the most discussed areas of the academic domain, especially when related to promoting learners' cognitive skills and problem-solving strategies. In Lebanon, however, students were increasingly underperforming in international tests such as TIMSS (Bou Nader et al., 2022; Sabbagh, 2023). These assessments showed that students in Lebanon had major gaps in application and reasoning abilities in NRMPs. Even the efforts made by students to cope with this situation were overshadowed by the traditional instructional strategies that emphasized the use of memory and rote learning over logical reasoning and other creative skills.

The purpose of this study was to examine the effect of Polya's structured problem-solving four-steps on developing students' problem-solving abilities.

This study was significant for it contributed to the body of existing literature about math education in the Lebanese context through highlighting a structured pedagogical approach that might enhance students' cognitive skills in solving NRMPs.

Problem Statement

Students were expected to apply higher-order thinking skills as they solved non-routine math problems, which

required deeper understanding of mathematical concepts in a completely new way that made use of students' acquired knowledge and cognitive skills in new contexts. Nevertheless, many students often found such problems challenging often due to the lack of adequate problem-solving strategies. In this regard, this study aimed to address the difficulties students faced in dealing with NRMPs through examining the effect of Polya-based instructional approach on the cognitive development of 14-15-year-old 9th grade students at 2 private schools in Lebanon.

Therefore, this study sought to answer this primary research question: Were there any effects of Polya's problem-solving steps on the difficulties faced by Lebanese private schools grade nine students when solving NRMPs?

Though this study provided valuable insights into the effect of Polya-based math instruction on grade 9 students' cognitive development when solving NRMPs, it still had some limitations, including the sample size, duration of the intervention, variability in instructional implementation of Polya's structured problem-solving approach, and other external factors such as classroom dynamics, students' prior knowledge and engagement levels that could not be controlled by the researcher. These

confines might limit the research potential to generalize the findings.

II. LITERATURE REVIEW

Non-routine mathematical problem-solving was one of the important objectives of mathematics education though it's still considered a difficult task, especially for middle school students starting to deal with more complex mathematical concepts (Olaniyan, 2015; Yayuk & Husamah, 2020). This section reviewed the existing body of literature demonstrating the effective role of Polya's problem-solving steps in enhancing students' problem-solving skills, particularly in Lebanese private schools.

De Corte et al. (2012) confirmed that problem-solving was an important aspect of mathematics education since it helped learners in the application of mathematical concepts as well as in stimulating and promoting thoughtful and creative ideas. Non-routine problems were those which did not have a direct answer, and this situation promoted students to apply higher-level thinking skills, including analysis, synthesis, and evaluation (Verschaffel et al., 2020). Still, the difficulties encountered by students while attempting to solve NRMPs often led to feelings of frustration and disengagement among them, thus, pointing to the necessity of having adequate and effective teaching methods which could facilitate students' learning (Gopinath & Lertlit, 2017).

El-Rouadi et al. (2015) pointed out that the difficulties faced by middle school students in solving complex math problems might stem from cognitive, emotional, and instructional factors that could hinder students' ability to engage in the learning process. Thus, overcoming these difficulties required the integration of different pedagogical approaches that might guide the teacher in developing targeted instructional strategies to enhance students' problem-solving skills. Cognitive difficulties included problems that students faced in the mental processes involved in understanding and solving NRMPs. This might refer to a difficulty in understanding the problem in terms of interpreting difficult keywords or phrases (Shawan et al., 2021), applying mathematical concepts on real-world situations (Kholid et al., 2022), or implementing multi-step problem-solving as in organizing their thoughts and managing sequence of operations needed to solve a NRMP (Shawan et al., 2021). Emotional factors could significantly impact students' confidence and motivation when dealing with NRMPs. These included math anxiety (Shehayeb & Anouti, 2018), fear of failure (Shawan et al., 2021), and lack of confidence (Thuan & Giang, 2023).

In addition to the cognitive and emotional factors that affect students' mathematical performance in solving NRMPs, findings from Shehayeb & Anouti (2018) indicated the significant impact of the implemented instructional approaches in engaging students' in the learning process and improving their problem-solving skills. According to the existing body of literature, the most critical instructional factors affecting students' limited performance in solving NRMPs included learners' limited exposure to problem-solving strategies as the

middle school curricula barely provided sufficient opportunities for students to practice NRMPs. Accordingly, students remained unfamiliar with this type of problem-solving activities and thus found it difficult (Gopinath & Lertlit, 2017).

Another educational challenge in solving NRMPs included inadequate teacher support due to teachers' math anxiety to solve NRMPs and lack of professional development, which could hinder their ability to teach problem-solving strategies (Naccache, 2022; Young & Dyess, 2021). Thus, teachers preferred to rely on traditional instructional approaches that supported rote learning and procedural tasks with minimal emphasis given to critical thinking and reasoning skills, a situation that kept students ill-equipped to tackle non-routine problems (Zaatari, 2022).

Moreover, the classroom's social dynamics like group work dynamics and lack of peer support might also affect students' experiences with NRMPs; for instance, though collaborative learning had the potential to improve students' problem-solving skills, it could also lead to miscommunication, unequal participation, and peer pressure (Shawan et al., 2021). As a result, students might feel misled or even overwhelmed by their peers during group discussions, which might negatively affect their learning experience (Thuan & Giang, 2023).

Therefore, the difficulties middle school students faced when solving non-routine math problems were multidimensional, including cognitive, emotional, pedagogical, and social collaborative challenges. Addressing these challenges required a holistic approach that included interactive instructional strategies, supportive classroom environments, and effective collaborative learning opportunities.

2.1 Hypothesis

To address the research question, the following hypothesis was formulated and statistically tested at significance level 5%. Thus, if $p\text{-value} < 0.05$, there would be enough evidence to reject the null hypothesis in favor of the alternative hypothesis.

It was hypothesized that there was a significant improvement in the problem-solving abilities of 9th graders in Lebanese private schools after the implementation of Polya's problem-solving steps when solving non-routine math problems.

This hypothesis was tested through the analysis of pre- and post-test data collected from the participating students, allowing for a comprehensive evaluation of the effectiveness of Polya's problem-solving four-steps in enhancing students' cognitive skills and problem-solving proficiency, as measured by Bodin's Taxonomy (2005; 2009).

2.2 Polya's Problem-Solving Steps

Polya's problem-solving structural framework included four stages: the first one was understanding the problem, the second one was devising a plan, the third one was carrying out the plan and the last one was looking back the solution (Polya, 1957). Every step was meant to assist the learners in going through a sequence of steps aimed at

solving the problem while enabling the learner to think and reflect on NRMP.

Understanding the problem focused on comprehending the given, conditions, and requirements of the problem. Evidence showed that students had difficulties in this phase, which affected the further steps (Aiyub et al., 2022). Thus, it was important for the students to focus on understanding the problem as a good basis for the problem-solving process.

In devising a plan, students started to devise the strategies to be used when approaching the problem. Studies showed that students who were able to get lessons on how to create plans systematically were most likely to be successful in solving NRMPs (Arslan & Altun, 2023). This phase encouraged learners to try out more than one method and to use different mathematical concepts, leading to creativity and cognitive flexibility (Siregar et al., 2022).

Carrying out the plan should be implemented as it was the most important part in NRMP. Research demonstrated that students who followed a structured approach, such as Polya's, were more likely to stay focused and organized during the problem-solving process (Sapri, 2023). This step highlighted the important aspect of organized thinking during solving NRMPs.

Looking back the solution was to evaluate the final output and the means used to achieve it. Polya (1945; 1954; 1957; 1973; 1981) considered this step as the post mastery process which was critical for practicing as well as refining one's skill. Research showed that learners who took time to assess themselves on these tasks acquired extensive knowledge on mathematical concepts and broadened their ways of dealing with NRMPs (Thuan & Giang, 2023).

Research suggested that the employment of Polya's problem-solving steps had the potential to improve students' mathematical skills. For instance, Olaniyan (2015) and Logoglu & Lutfi (2017) highlighted that students who thought within Polya's framework were more skilled in

solving higher level complex mathematical problems than their counterparts who were taught in the traditional way. In the same vein, Lee (2017) noted that the lesson development using Polya's approach improved the conditions of teaching and learning and made students more engaged in the learning process, willing to learn, and better comprehending and connecting mathematical concepts.

In the context of Lebanese private schools, it was expected that integrating Polya's problem-solving structured approach in the educational process could organize grade 9 students' thinking in solving NRMPs as the structured nature of Polya's framework might provide learners with the required tools for complex problem-solving.

2.3 Taxonomy of Bloom (1957) and Anderson and all (2001) as viewed by Bodin (Bodin, A., 2010)

Bodin's taxonomy was a hierarchical framework designed to classify levels of knowledge, understanding, and application, particularly in the context of mathematics. It consisted of several main categories, each with

subcategories that defined specific cognitive processes. The first category was knowledge, in which Bodin viewed it in terms of facts, vocabulary, tools, and procedures and labelled these subcategories to A1, A2, A3, and A4 respectively. Facts involved recognizing and applying definitions, properties, and theorems. Vocabulary comprised understanding and using mathematical terms; tools included being familiar with mathematical tools, and procedures involved the ability to execute algorithms and procedures automatically. The second category in Bloom's taxonomy: understanding was divided by Bodin into six sublevels: B1 to B6. These covered facts: producing examples and analyzing mathematical texts, vocabulary: deepening understanding of terms, tools: understanding the use of tools in context, procedures: justifying and explaining procedures, relations: highlighting relationships between concepts, and situations: analyzing and interpreting mathematical situations. The third level in Bloom's taxonomy was classified by Bodin in three sublevels from C1 to C3 including applications in simple familiar situations: applying tools and procedures in straightforward contexts, applications in average familiar complex situations: handling more complex applications, and applications in familiar complex situations: engaging with intricate problems requiring multiple steps. Additionally, Bloom's creativity was divided by Bodin into three subcategories, including D1, which reflected the use of known tools in new situations, adapting and extending familiar methods, D2, through which new ideas would be demonstrated while generating personal insights based on training and experience, and D3, which included the creation of tools and personal approaches, innovating new methods and tools. Moreover, Bloom's evaluation was viewed by Bodin in terms of E1 and E2 reflecting the production of judgment and auto-evaluation respectively.

The taxonomy indicated that each level was more advanced than its preceding one which required a greater comprehension as well as more complex thinking processes. Bodin's view of Bloom's taxonomy was useful in the processing of non-routine math problems due to its logical framework, which helps in developing creativity, encouraging self-assessment skills, strengthening mathematical concepts, and facilitating metacognitive practices.

2.4 Vygotsky's Theoretical Framework Underpinned by Polya's Empirical Evidence

This research was based on the constructivist learning theories, principally those developed by Vygotsky, Bruner, and Polya, which suggested that knowledge was not passively acquired but was actively constructed by learners based on their experiences and interactions with the learning environment.

Vygotsky's Social Constructivism emphasized the role of social interaction and culture within which cognition develops. The Zone of Proximal Development (ZPD) concept assumed that learners achieved more with the assistance of more competent peers or teachers. This was in accordance with Polya's conceptual framework as this

shared use of the problem-solving steps was expected to enhance students' learning (Vygotsky, 1962; 1978).

Additionally, Bruner accentuated the significance of scaffolding in education since students might not possess all the required skills to achieve higher level of understanding. Polya's steps could be seen as a way of guiding students through the process of problem-solving and then gradually reducing support as learners became more skilled. This encouraged students' self-confidence while solving NRMPs (Bruner, 1961; 1986).

As well, Polya's problem-solving framework provided instructive contributions on education problems and suggested a method that was compatible with the philosophy of constructivism. The four steps of understanding, planning, undertaking, and revising gave students the impression that the learning process was cyclic in that imparting knowledge was gained through further practice and reflection (Polya, 1954; 1957).

The study at hand was supported and backed up by Vygotsky's and Bruner educational theories which emphasized the role of collaboration in developing students' cognitive abilities and promoting solving NRMPs.

III. METHODOLOGY

3.1 Research Design

This research implemented a quasi-experimental design to examine the effect of Polya's problem-solving steps on improving NRMPs problem-solving skills of 14-15-year-old grade 9 students at two private schools in Beirut, Lebanon. This design allowed comparing students' problem-solving skills before and after the intervention, which included the implementation of Polya's problem-solving steps in solving NRMPs.

3.2 Participants

The population for this study consisted of 9th-grade students enrolled in Lebanese private schools. A purposive and convenience sampling techniques were applied to select a sample of 67 (36 for the experimental group and 31 for the control group) students, aged 14-15 year old from two private schools that agreed to participate in the study. While the experimental group received the intervention based on Polya's problem-solving steps, the control group continued with their regular mathematics instruction without the intervention.

3.3 Instruments

The study used quantitative instrument to assess the effectiveness of Polya's problem-solving steps. Two tests of NRMPs were developed to measure students' problem-solving abilities in solving NRMPs before and after the intervention. One test was administered before the intervention (pre-test) and another test after the intervention (post-test) to evaluate changes in students' mathematical performance, as measured by Bodin's Taxonomy.

3.4 Intervention

The intervention consisted of a structured instructional approach based on Polya's four-step problem-solving

framework. First, students learned to identify and communicate the problem. Second, they were guided to develop strategies for solving the problem. Third, students implemented their strategies to carry out the plan and find solutions.

The intervention was conducted over a period of two weeks, with two sessions per week, each lasting 50 minutes. During these sessions, students engaged in collaborative group activities that encouraged social interaction and multiple solution approaches to non-routine math problems. The integration of Polya's steps in math was implemented by the teacher, who received comprehensive training on the effective implementation of Polya-based instructional approach in math problem-solving, in the presence of the researcher.

3.5 Data Collection Procedures

- Pre-Test Administration: Prior to the intervention, a pre-test with NRMPs was administered to assess students' initial problem-solving abilities and identify specific difficulties faced in solving NRMPs.
- Implementation of the Intervention: The teacher facilitated the instructional sessions, ensuring that all students received consistent exposure to Polya's steps. All sessions were observed by the researcher.
- Post-Test Administration: After the intervention, a post-test with new NRMPs, was administered to assess any changes in students' problem-solving cognitive performance.

IV. DATA ANALYSIS

Quantitative data using pre-post tests were analyzed through the Statistical Package for the Social Sciences (SPSS). 'Descriptive statistics' were computed for summarizing data while inferential statistics paired t-test and independent sample t-test were used to examine if there were any significant differences in students' cognitive performance before and after the intervention as well as between the experimental and the control groups regarding their problem-solving skills. To measure students' cognitive performance in solving NRMPs, the pre-posttests included Bodin's levels quantified and coded accordingly as followed: A1=1, A4=4, B1=5, B3=7, B5=9, C1=11, C3=13, D1=14, D2=15, and D3=16.

4.1 Descriptive Statistics Bodin's Level Scores of Grade 9 students

The table presented data on Bodin's Level scores of Grade 9 students in the control group and the experimental group. The data was presented for three different points: pre-posttest p1, pre-posttest p2, and pre-posttest p3.

In pretest p1, 68.7% of grade 9 students either had a wrong or blank answer in solving NRMP p1, 23.9% of students performed at level A1 (facts, including recognizing and applying definitions, properties, and theorems) and 7.5 % achieved C1 (application in simple familiar situations, applying tools and procedures in straightforward contexts).

In pretest p2, 85% of students were unable to solve NRMPs, 10.5 % performed at level B5 (relations,

highlighting relationships between concepts), 1.5% were able to demonstrate cognitive ability at D1 level (use of known tools in new situations, adapting and extending familiar methods) level and 3% at D3 level (creation of tools and personal approaches, innovating new methods and tools).

In pretest p3, all students were at Bodin's Level 0; i.e., either had a wrong or blank answer in solving NRMP.

As for the posttest, Bodin's level scores for grade 9 students demonstrated a shift towards higher levels. Both groups showed a noticeable shift towards higher Bodin's Levels in the posttest compared to their pretest performance. This suggested that both instructional approaches had a positive impact on students' learning, yet the experimental group demonstrated a more

noticeable shift towards higher levels compared to the control group, particularly in reaching levels B5 and D3.

In posttest p1, the percentage of students who got 0 declined to 31.3%. Besides, 20.9% were able to execute algorithms and procedures automatically, 34.4% were able to demonstrate understanding of using tools in context (B3) and ability to highlight relationships between concepts (B5), whereas 26.9 % achieved D3 level (creation of tools and personal approaches, innovating new methods and tools).

In posttest p2, 71.6% of grade 9 students showed a significant shift towards level B5, with only 28.4% remaining at level 0.

Similarly, in posttest p3, 47.8% of 9th graders demonstrated a significant shift towards level D3, creativity in solving NRMPs.

Group Statistics

	Group Type	N	Mean	Std. Deviation	Std. Error Mean
Pretest Scores P1	Control	31	.10	.301	.054
	Experimental	36	1.89	3.740	.623
Posttest Scores P1	Control	31	4.39	5.696	1.023
	Experimental	36	9.22	6.100	1.017
Pretest Scores P2	Control	31	1.45	3.365	.604
	Experimental	36	1.78	4.648	.775
Posttest Scores P2	Control	31	7.26	3.614	.649
	Experimental	36	5.75	4.384	.731
Pretest Scores P3	Control	31	.00	.000 ^a	.000
	Experimental	36	.00	.000 ^a	.000
Posttest Scores P3	Control	31	7.74	8.128	1.460
	Experimental	36	7.56	8.101	1.350

a. t cannot be computed because the standard deviations of both groups are 0.

The tables of descriptive statistics comparing pretests and posttests within the same group and between control and experimental groups provided valuable insights into the effectiveness of Polya's problem-solving steps. The study involved two groups: an experimental group (36 students) that received instruction based on Polya's problem-solving steps and a control group (31 students) that continued with regular instruction.

As for pretest and posttest scores, the table presented mean scores and standard deviations for both pretest and posttest assessments across different problem types (p1, p2, p3). As demonstrated in the differences in mean scores between the pretest and posttest, both groups demonstrated improvement from pretest to posttest, but the experimental group consistently showed a more substantial shift towards a higher mean score, particularly in posttest p1. This suggested that the instructional approach (Polya's problem-solving) used in the experimental group might have been more effective in promoting student learning and development of higher order cognitive skills while solving NRMP p1.

Results from the experimental group demonstrated pretest scores p1, the mean pretest score was 1.89 with a standard deviation of 3.74, indicating a wide range of initial abilities. The posttest scores for p1 increased significantly to 9.22 with SD = 6.1, suggesting substantial improvement after the intervention. This increase from

pretest to posttest scores indicated that the students in the experimental group benefited from the structured approach, as evidenced by the large difference in means.

However, results from the control group indicated that pretest scores had a mean of 0.10 with SD = 0.3 for p1, indicating very low initial problem-solving abilities. The mean posttest score for p1 was 4.39 with SD = 5.69, showing some improvement, but not nearly as significant as that of the experimental group. For the first NRMP, the control group's improvement was modest compared to that of the experimental group, suggesting that traditional instruction did not effectively enhance students' problem-solving skills relevant to NRMPs.

Accordingly, for p1, the experimental group's posttest mean score (9.22) was significantly higher than the control group's posttest mean score (4.39). This difference indicated that the intervention had a positive impact on the experimental group's problem-solving abilities, mainly observed in p1.

Descriptive data analysis revealed that the implementation of Polya's problem-solving steps had a significant potential to enhance grade 9 students' cognitive skills when solving NRMPs. The substantial increase in posttest problem 1 score for the experimental group, coupled with the modest improvements in the control group, underscored the effectiveness of structured problem-solving strategies in mathematics education.

However, this wasn't the case with respect to the NRMPs p2 and p3, where the mean scores of the control group were much higher (7.26) and (7.74) than those of the experimental group (5.75) and (7.56) respectively.

Normality Test

Before conducting the relevant t-tests, it was essential to evaluate the normality of the distributed data, as the t-test assumed that the dependent variable was approximately normally distributed, particularly in small samples.

Violations of this assumption could lead to inaccurate p-values and confidence intervals, thereby compromising the validity of statistical inferences. Thus, conducting Shapiro-Wilk normality test ensured the appropriateness of the t-test or indicated the need for non-parametric alternatives like Mann-Whitney U Test instead of independent-sample t-test (between group comparison: control vs. experimental) and Wilcoxon Signed-Rank Test instead of paired t-test (within group comparison: pre vs. post).

Tests of Normality						
	Kolmogorov-Smirnov ^a			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Pretest Scores P1	.434	67	.000	.384	67	.000
Posttest Scores P1	.203	67	.000	.821	67	.000
Pretest Scores P2	.506	67	.000	.446	67	.000
Posttest Scores P2	.450	67	.000	.565	67	.000
Posttest Scores P3	.351	67	.000	.636	67	.000

As results from the normality test showed p-value = 0.000, the data was not normally distributed, and thus, independent sample t-test and paired sample t-test were

substituted by their non-parametric equivalents: Mann-Whitney U Test and Wilcoxon Signed-Rank Test respectively.

Inferential Statistics

Test Statistics^a

	Pretest Scores P1	Posttest Scores P1	Pretest Scores P2	Posttest Scores P2	Pretest Scores P3	Posttest Scores P3
Mann-Whitney U	325.500	314.500	553.000	464.500	558.000	551.500
Wilcoxon W	821.500	810.500	1219.000	1130.500	1224.000	1217.500
Z	-3.592	-3.169	-.102	-1.506	.000	-.094
Asymp. Sig. (2-tailed)	.000	.002	.919	.132	1.000	.925

Mann-Whitney U Test; a. Grouping Variable: Group type

Mann-Whitney U Test was used instead of the independent sample t-test to compare the mean scores of the two independent groups (control x experimental) in order to determine whether

there was a statistically significant difference between them. Based on the results of Mann-Whitney U Test, there was a significant difference in solving NRMPs between the experimental and control groups before the intervention where p-value = 0.00 and after the intervention where p-value = 0.002 in solving the NRMP p1, indicating the intervention's success only in solving

NRMP p1. However, this difference in students' performance when solving NRMPs was not statistically observed in the NRMPs p2 and p3 where p-values were greater than 0.05.

Thus, the intervention likely caused a measurable change in the experimental group compared to the control group only in solving NRMP p1. However, in solving the NRMP p2 and p3, there was no statistically significant difference in solving NRMPs between the experimental and the control group

Test Statistics^a

	Posttest Scores P1 - Pretest Scores P1	Posttest Scores P2 - Pretest Scores P2	Posttest Scores P3 - Pretest Scores P3
Z	-5.329 ^b	-5.409 ^b	-5.657 ^b
Asymp. Sig. (2-tailed)	.000	.000	.000

Wilcoxon Signed Ranks Test

Additionally, Wilcoxon Signed-Rank Test (Within Groups, Pretest vs. Posttest) was used instead of the paired sample t-test to evaluate whether there was a significant difference in solving NRMPs within the experimental group over time (e.g., pretest vs. posttest). All posttest vs. pretest comparisons had $p = 0.000 < 0.01$, indicating a significant improvement in scores after the intervention

within the experimental group. Thus, the intervention significantly improved the experimental group ability to solve NRMPs.

Therefore, there was a significant effect of integrating Polya's problem solving steps in solving NRMPs indicated by the significant improvement within the experimental group who outperformed the control group

after the intervention, specifically in solving the NRMP p1.

That is, when comparing 9th graders' mathematical performance in solving NRMPs between the control and experimental group, findings suggested that the experimental group outperformed the control group only in solving problem 1; however, while comparing whether there was a significant difference in the mathematical performance of the experimental group before and after the intervention, it was indicated that participants demonstrated better cognitive skills in solving NRMPs after the intervention.

V. DISCUSSIONS AND CONCLUSIONS

This study aimed at examining the effectiveness of Polya's steps in improving students' problem-solving abilities in NRMPs, which required higher-order thinking, deeper understanding of mathematical concepts and the ability to apply knowledge in new situations. Accordingly, it was hypothesized that the implementation of Polya's problem-solving steps in math instruction would enhance grade 9 students' cognitive skills in solving NRMPs.

Based on the afore-mentioned within group analysis, the pretest posttest p-values were $0.00 < 0.01$, indicating a strong significant improvement in mean scores after the intervention within the experimental group. Thus, the intervention significantly improved the experimental group's problem-solving skills in solving NRMPs.

Accordingly, H1 was accepted ($p\text{-value} = 0.00 < 0.01$), indicating that there was a significant improvement in the problem-solving abilities of 9th graders in Lebanese private schools after the implementation of Polya's problem-solving steps when solving non-routine math problems.

However, while comparing the performance of the experimental group to that of the control group, it was demonstrated that the experimental group significantly outperformed the control group only in solving the NRMP p1 posttest, where the p-value was $0.002 < 0.01$. This difference in mean scores between the experimental and the control group was not observed in solving the NRMPs p2 and p3. The experimental group's posttest mean score (9.22) was significantly higher than that of the control group's posttest mean score (4.39). This difference indicated that the intervention had a positive impact on the experimental group's problem-solving abilities only in solving the NRMP p1, if compared to the problem-solving abilities of the control group. Thus, results showed that there was a significant difference in solving NRMPs between the experimental and the control group in solving the NRMP p1 only: pretest and post-test, where p-values were 0.000 and $0.002 < 0.01$ respectively, indicating the intervention's success only in solving NRMP p1.

The findings from this study contributed to the growing body of literature on effective mathematics education strategies, emphasizing the importance of instructional frameworks that would empower students' learning. By implementing Polya's problem-solving structured approach, educators could enhance students' cognitive

skills, reduce difficulties with NRMPs, and promote deeper understanding of mathematical concepts. This research highlighted the need for continued exploration of pedagogical approaches that promoted critical thinking and problem-solving proficiency among students, ultimately preparing them for future academic and real-world challenges.

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Electronic and Optical Properties of Polypropylene/SrTiO₃ Polymer Semiconductor Composite: A First-Principles CASTEP Study

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Abstract. Semiconductor polymer composite materials have been receiving considerable interest with regards to their potential use in flexible electronic devices, dielectric devices, energy storage devices, and optoelectronic devices. Polypropylene is a polymer commonly used due to its good chemical stability and mechanical strength. However, the wide bandgap of polypropylene does not allow its direct use in electronic devices. The incorporation of inorganic fillers such as strontium titanate is considered to be a good option to modify the electronic properties of the polymer.

In the current study, the structural, electronic, and optical properties of the 7 wt% SrTiO₃/PP composite system have been investigated using the Density Functional Theory (DFT) method with the CASTEP tool of Materials Studio software. The structural configurations of the composite system have been calculated to confirm the existence of good interface interactions between the polymer matrix and the ceramic particle. The electronic bandgap of the composite system is found to be decreased compared to the pristine polypropylene system.

The partial DOS analysis of the composite system shows the contribution of the titanium 3d orbitals and the oxygen 2p orbitals to the Fermi level, which is helpful for the transfer of electrons between the interface. The optical properties such as the dielectric function, absorption coefficient, refractive index, reflectivity, optical conductivity, and energy loss function have been calculated over a range of 0 to 30 eV incident photon energy. The results show good optical absorption behavior of the composite system.

Index Terms: Polypropylene, Strontium Titanate, DFT, Band Structure, Optical Properties, Semiconductor Composites

I. INTRODUCTION

Polymer-based semiconductor composites have been the subject of much attention in recent times, especially in the context of their potential applications in flexible electronics, optoelectronics, energy storage, and high-performance dielectrics [1]–[3]. These materials have been seen to exhibit some advantages over traditional inorganic semiconductors, such as lower density, mechanical flexibility, chemical stability, corrosion resistance, and ease of processing [4]–[6]. Among the different types of thermoplastic polymers, polypropylene (PP) has been the preferred material for the development of polymer-based semiconductor composites, especially because of its good chemical resistance, mechanical properties, and processability [7]. Nevertheless, the material has been seen to exhibit a large band gap, thus limiting its direct application in the development of electronic and optoelectronic devices [8], [9]. In order to overcome the problems associated with the material, the addition of inorganic nanostructures to the polymer matrix has been seen to be a viable approach to improving the electronic and optical properties of the material [10], [11]. Hybrid polymer-ceramic composites have been seen to

exhibit the advantages of polymers and the high electrical, dielectric, and optical properties of ceramics [12]. In the context of the development of polymer-based semiconductor composites, strontium titanate (SrTiO₃) has been seen to be a promising material, especially because of its high dielectric constant, tunable band gap, and good optical absorption in the ultra violet region [13]–[15]. In the earlier investigations have shown that the addition of SrTiO₃ and other metal oxides, such as TiO₂ and ZnO, to the polymer matrix has been seen to improve the charge transport, dielectric, and optical properties of the material [16]–[18].

Recent developments in the field of computational materials science, such as first-principles calculations using DFT, have been shown in the direction of a proficient tool to study the electronic and optical properties of complex systems at the atomic scale [19], [20]. Material Studio & CASTEP module using the plane wave pseudo potential method with the generalized gradient approximations (GGA) have extensively applied on the way to scrutinize the features of polymer-inorganic hybrid systems [22], [23]. Although there is considerable interest in the PP/SrTiO₃ composite system, there is a lack of first-principles study of the structural, electronic, and

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optical properties of the system. These features engage in recreation a vital part in guiding and design of the next generation of polymeric semiconductors for flexible electronics and optoelectronic devices. Therefore, aspire of the current investigation is toward elucidate the influence of 7 wt% SrTiO₃ incorporation into polypropylene using DFT-based calculations. The objectives of this study include evaluating the structural stability of the system, analyzing the electronic band structure and density of states, and investigating key optical properties such as the dielectric function, absorption coefficient, refractive index, optical conductivity, reflectivity, and energy loss function

II. COMPUTATIONAL METHODOLOGY:

All calculations in the present work have been carried out using the CASTEP module of the Materials Studio package, which is developed based on density functional theory (DFT) [22]. In this investigation, the exchange correlation potential was evaluated within the generalized gradient approximation (GGA) of the Perdew-Burke-Ernzerhof (PBE) functional, which is the most commonly used method to analyze the structural and electronic properties of condensed matter systems.

The computational structural models developed in this work are depicted schematically in Fig. 1, which shows the optimized structural models of (a) SrTiO₃, (b) polypropylene (PP), and (c) the PP/SrTiO₃ composite system. From the structural model of the SrTiO₃ perovskite compound depicted in Fig. 1a, it is evident that the compound assumes a cubic perovskite structure with the Strontium (Sr) atoms at the corner sites, the Titanium (Ti) atoms at center of the unit cell, and the Oxygen (O) atoms at the face-centered position of the unit cell. In the perovskite structure of the compound, the oxygen atoms form octahedral units around the Titanium atoms. This structure is well known for its high dielectric properties.

The polymer structure depicted in Fig. 1b refers to a polypropylene chain formed from the polymerization of a number of propylene (C₃H₆) units. In the polymer structure, the backbone of the polymer is formed from the carbon atoms of the polymer chain, with hydrogen atoms attached to the polymer chain [7].

In order to generate the composite structure, the optimized chain of polypropylene was combined with the structure of SrTiO₃, as depicted in Fig. 1(c). This configuration of the structure represents a hybrid interface between the polymer matrix and the filler material. The composition of the structure was chosen to be around 7 wt% of SrTiO₃, as represented in the periodic supercell model. The structure of the interface was carefully designed to facilitate the interaction between the two phases of the polymer-ceramic material, thereby allowing the analysis of the electronic interaction at the interface.

The geometry of the structure was optimized in order to achieve the minimum energy configuration of all the systems. The convergence criteria of the optimization process were set at high values in order to achieve high accuracy during the computation, as represented by the tolerance of the overall energy at 1×10^{-5} eV/atom,

maximum force of 0.03 eV/Å, and stress tolerance within acceptable limits. The cutoff energy of 500 eV was chosen as a basis of the plane wave, while integration over the Brillouin zone was carried out using by the Monkhorst-Pack k-point grid of $3 \times 3 \times 3$.

With the aim of achieve the better understanding of the electronic properties of the structure, the electronic structure was calculated, as represented by the band structure, total density of states (DOS), and partial density of states (PDOS). The optical properties of the structure were designed by means of the frequency-dependent dielectric function within the linear response formalism as implemented in the CASTEP code [22], [23].

This method of computation allows a better understanding of the properties of the PP/SrTiO₃ composite structure, thereby allowing a better basis of predicting its performance in various optoelectronic applications.

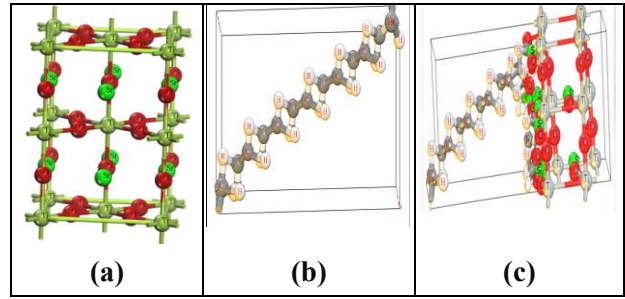


Figure 1: Optimized atomic structures of (a) cubic perovskite SrTiO₃, (b) polypropylene (PP) chain, and (c) PP/SrTiO₃ composite system representing ~7 wt% filler loading. The composite structure illustrates the interfacial interaction between the polymer matrix and inorganic SrTiO₃ phase.

III. RESULTS AND DISCUSSION:

3.1 Band Structure Analysis

The electronic band structure for the PP/SrTiO₃ composite material has provided valuable insights into the semiconducting properties and charge transport for the material. The investigated band structure for the material along the high-symmetry information within the Brillouin zone is depicted in Fig. 2. This has provided a clear indication of the energy level distribution for the material.

As depicted in the band structure, the energy gap is evident between the VBM and CBM, indicating the semiconducting properties for the material. The energy gap is seen to be reduced for the PP/SrTiO₃ composite material compared to the energy gap for the pure polypropylene material, which is characterized by a large insulating energy gap [8]. This reduction in the energy gap for the PP/SrTiO₃ material could be attributed to the effect of SrTiO₃, which has been introduced into the material [13,18].

A comprehensive investigation of the band dispersion validates the presence of flat bands around the valence region, which is indicative of the localized electronic states present in the polymer system. These localized states arise as a result of the covalent nature of the polymer backbone [7]. Conversely, the conduction band shows the presence of dispersive features, especially around the

regions where SrTiO_3 is present. The dispersive feature observed around the conduction band indicates presence of delocalized positions, which result in the enhanced transport of charge carriers [19].

The effect of SrTiO_3 is quite significant as the presence of the 3d orbitals of the titanium atom results in the creation of additional electronic states around the conduction band edge. This results in the enhanced overlap of the electronic states, thereby facilitating the transfer of charge carriers across the polymer-ceramic interface [13], [17]. The presence of SrTiO_3 reduces the band gap as well as the electronic conductivity of the system.

These investigations show that the formation of the PP/ SrTiO_3 heterojunction emphasizes a vital mechanism for tailoring the electronic characteristics of the material, construction it a potential aspect for relevance in flexible electronics and optoelectronic devices.

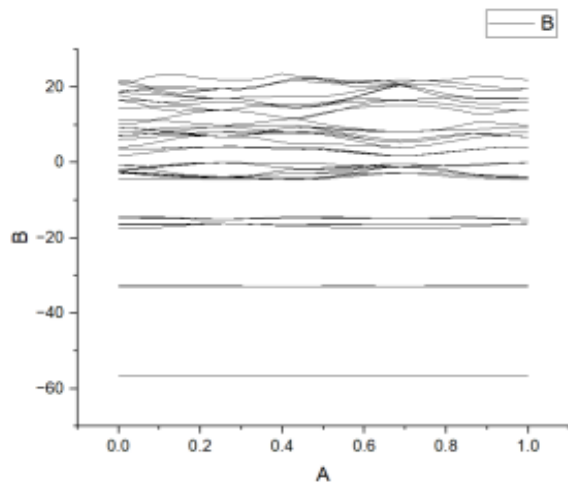


Figure 2: The investigated electronic band structure of the PP/ SrTiO_3 composite is shown within the irreducible Brillouin zone. The Fermi level is set at 0 eV. A band gap is seen connecting the valence and conduction bands, which indicates a semiconductor property. Flat valence bands indicate localized states in the matrix, while more dispersed conduction bands indicate increased mobility of electrons.

3.2 Density of States (DOS) Analysis:

The total density of states (DOS) of the PP/ SrTiO_3 composite, as depicted in Fig. 4, offers a detailed description of the electronic states available in a given energy level. It is worth noting that, in addition to band structure calculations, DOS calculations offer an understanding of the contribution of individual atomic orbitals to the electronic states of a compound.

Generally, the DOS plot is characterized by three distinct energy regions, with the deep valence region, which lies in the lower energy region, dominated by bonding states of the polymer's carbon and hydrogen atoms [7]. As such, this region contributes very little to the conduction of electricity in polymers. Furthermore, in the upper valence region, there is a considerable contribution of both carbon and oxygen orbitals, suggesting strong hybridization between the polymer and SrTiO_3 , which is crucial in

enhancing electronic coupling between them, thus facilitating charge transfer.

The conduction band is mainly dominated by the Ti-3d states of SrTiO_3 and has a minor contribution from the oxygen 2p states, similar to the earlier results of the DFT calculations for perovskite metal oxides [13], [18]. The dispersive conduction states help in the mobility of the charge carriers at the polymer-ceramic interface, which is consistent with the trends of the electronic band structure. The presence of the SrTiO_3 states near the conduction band edge effectively reduces the band gap with respect to pure polypropylene and thus enhances the semiconducting characteristics of the material.

From the DOS analysis, it is clear that the hybrid composite PP/ SrTiO_3 indeed possesses a hybrid electronic structure with the polymer contributing to the localized states in the valence band and the ceramic contributing to the delocalized states in the conduction band. This hybridization is the key factor that enhances the electronic and optical properties of the composite and makes it a promising candidate for the fabrication of flexible electronics and optoelectronics devices.

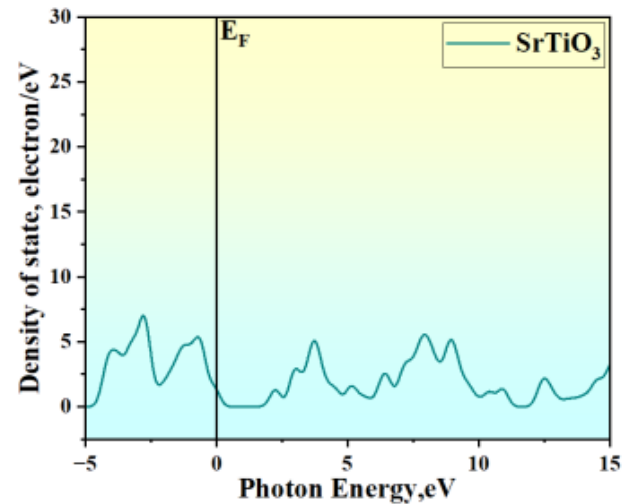


Figure 3: Total density of states (DOS) of the PP/ SrTiO_3 composite as a function of energy. The Fermi level is set at 0 eV. The deep valence region is dominated by polymer states, while hybridization with SrTiO_3 oxygen orbitals occurs in the upper valence region. The conduction band is primarily contributed by Ti 3d states, indicating enhanced electronic conductivity

3.3 Partial Density of States (PDOS)

Partial density of states (PDOS) offers profound insight into the involvement of different atomic orbitals to the electronic structure of the PP/ SrTiO_3 composite system. The calculated PDOS spectra of the different constituent atoms of the composite system have been shown in Fig. 4.

As can be seen from the PDOS spectra shown in Fig. 4, the valence band region is mainly composed of the contributions of the C-2p orbitals of the polypropylene backbone and the O-2p orbitals of the SrTiO_3 component of the composite system. The hybridization between the different states is evident from the overlapping region of the states.

Hybridization is the overlapping of the states of the different components of the composite system, which is very important to alter the electronic properties of the composite system as well as to allow the charge transfer across the interface [13, 18].

Conversely, the conduction band is subjugated by the states of Ti-3d orbitals, which form the major empty electronic states. This emphasizes enhancement in the electronic conductivity of the composite system due to the d-orbitals forming more energy states near the conduction band minimum. This can be explained by considering the well-known electronic structure of perovskite oxide compounds, where the d-states of TM significantly influence the conduction properties [17], [19].

In the case of Sr orbitals, their contribution to the composite system is minimal and occurs at a deeper level of energy states. This indicates that the structural contribution of Sr to the perovskite structure occurs without any electronic contribution to the composite system [13]. On the other hand, the contribution of the hydrogen orbitals to the electronic states near the Fermi level is minimal, such as saturated hydrocarbon compounds [7].

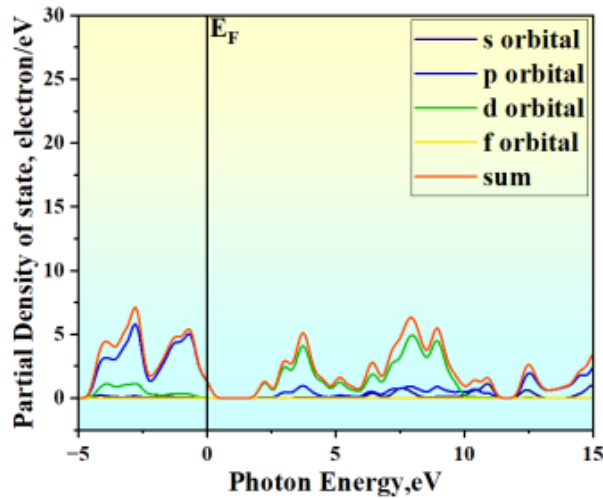


Figure 4: Partial density of states (PDOS) of the PP/SrTiO₃ composite showing the contributions of C, H, O, Ti, and Sr atoms. The valence band is mostly conquered by C-2p and O-2p states, indicating hybridization between the polymer matrix and SrTiO₃. The conduction band is primarily governed by Ti-3d states, which contribute to enhanced electronic conductivity. Minimal contribution from Sr and H states near the Fermi level is observed.

3.4 Optical Properties

The optical properties of the PP/SrTiO₃ nanostructure are determined by interband electronic transitions, interfacial polarization, and charge transfer between the polymer matrix and perovskite oxide. These characteristics can be illustrated as to the complex dielectric function, which offers a broad perceptive of the interaction involving light as well as matter of nanostructure.

3.4.1 Dielectric Function

The multifaceted dielectric function is classified as $\epsilon(\omega) = \epsilon_1(\omega) + i\epsilon_2(\omega)$. The real part represents polarization and

energy storage capability, while the imaginary part represents photon absorption via inter band transitions [15], [18].

As illustrated in Fig. 5, the elevated static dielectric constant in the low-energy region is due to interfacial (Maxwell-Wagner-Sillars) polarization caused by charge accumulation at the interface of PP and SrTiO₃. This phenomenon is more prominent in heterogeneous systems where materials with different dielectric constants are used in combination [14].

With increasing photon energy, the value of $\epsilon_1(\omega)$ decreases due to reduced polarization response, which represents normal dispersion. At the same time, pronounced peaks are found in $\epsilon_2(\omega)$, which are due to electronic transitions from O 2p to Ti 3d orbitals. This confirms strong electronic coupling and enhanced optical activity due to SrTiO₃ incorporation.

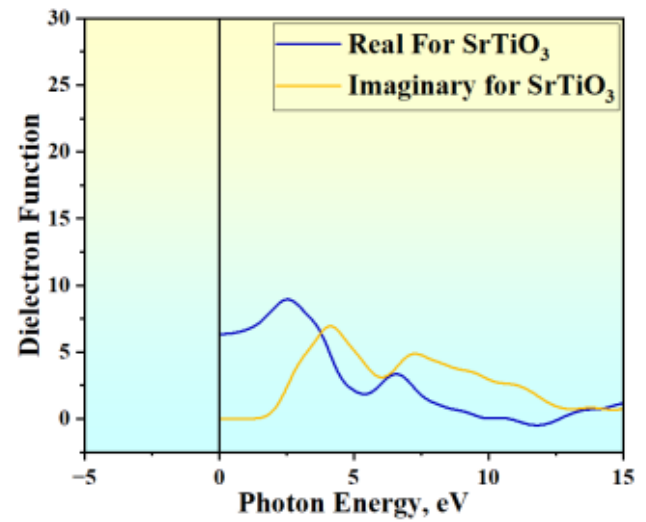


Figure 5: The dielectric spectra demonstrate strong low-energy polarization due to interfacial effects and pronounced ϵ_2 peaks linked to O-2p $\rightarrow$ Ti-3d transitions, highlighting the role of SrTiO₃ in tuning the optical response.

3.4.2 Absorption Coefficient

The absorption coefficient (Fig. 6) is a measure of the probability of electronic transitions caused by photon absorption. The absorption edge is consistent with the calculated band gap.

The steep increase in absorption in the UV region is characteristic of direct interband transitions dominated by Ti-3d conduction bands. In comparison to pure polypropylene, where absorption is negligible due to the insulating character of the polymer, the composite shows substantial enhancement in optical absorption due to the additional states from the SrTiO₃ component [13], [16].

In addition, the broad absorption curve indicates the contribution of localized interface states to facilitate sub-band gap transitions for more efficient photon harvesting, a critical issue for optoelectronics and solar cells.

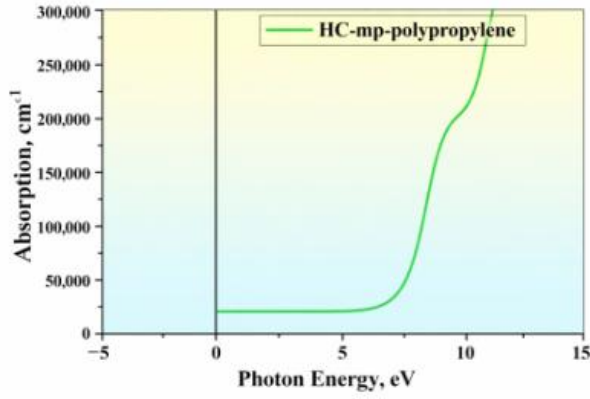


Figure 6: The absorption edge confirms band gap transitions, while strong UV absorption highlights the dominant role of Ti-3d states and interfacial electronic coupling.

3.4.3 Reflectivity

The reflectivity spectrum (Fig. 7) indicates that reflectance is low in the visible region and low-energy range, implying that light is being effectively absorbed.

With increasing photon energy, reflectance is increased due to increased oscillation of electrons. Low reflectance is an indicator of increased light-trapping capability, which is of prime importance for applications in solar cells and photodetectors [15].

The above phenomenon may be attributed to the heterogeneous interface, where multiple scattering of photons occurs.

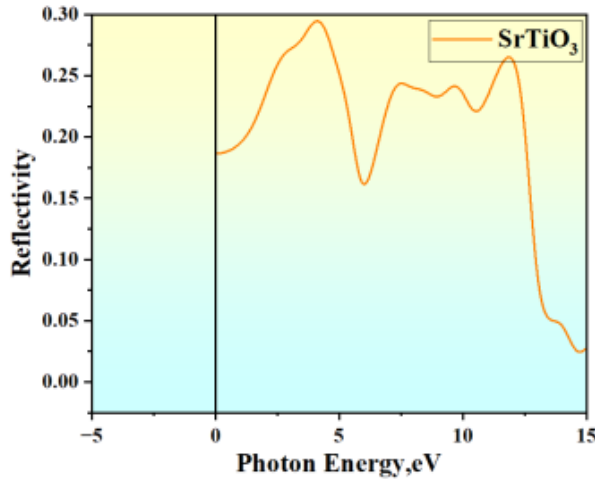


Figure 7: Low reflectivity at lower energies confirms efficient light absorption, while increased reflectivity at higher energies is associated with electronic excitation and dielectric response.

3.4.4 Refractive Index

The refractive index (Fig. 8) is significantly affected by the electronic polarizability of the system. The high refractive index at low photon energy implies a strong interaction between electromagnetic waves and bound electrons.

The gradual decrease in refractive index with increasing photon energy corresponds to normal dispersion, which is in agreement with classical electromagnetic theory. The

absence of anomalous dispersion implies stable optical properties without resonance-induced distortion [16].

Most importantly, the increased refractive index in comparison to pure PP implies the presence of SrTiO₃ in the composite material, which is important for its potential use in waveguides, coatings, etc.

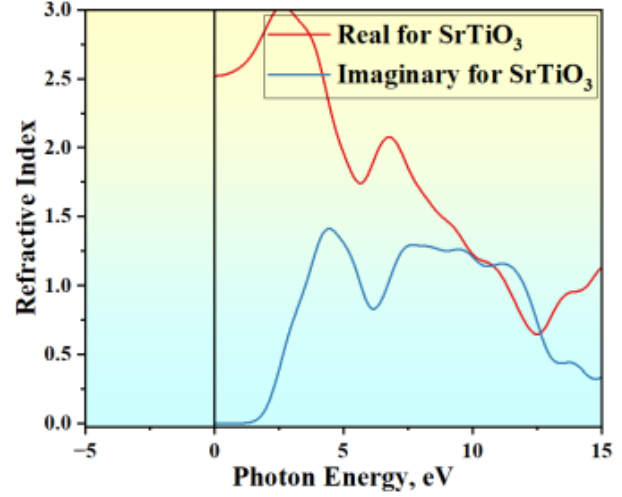


Figure 8: The high refractive index at low energies reflects strong polarization effects, while the decreasing trend confirms stable dispersion characteristics.

3.4.5 Optical Conductivity

The spectrum in Figure 9 represents the conductivity spectrum for light. The low energy region in the spectrum represents low conductivity due to insufficient photon energy to excite electrons.

The sharp increase in conductivity in Figure 10 represents an increased promoting of electrons commencing the valence band to the conduction band, thus confirming the semiconductor material characteristics.

The presence of SrTiO₃ in the device also helps in delocalizing charge carriers. This is an added advantage for optoelectronic devices.

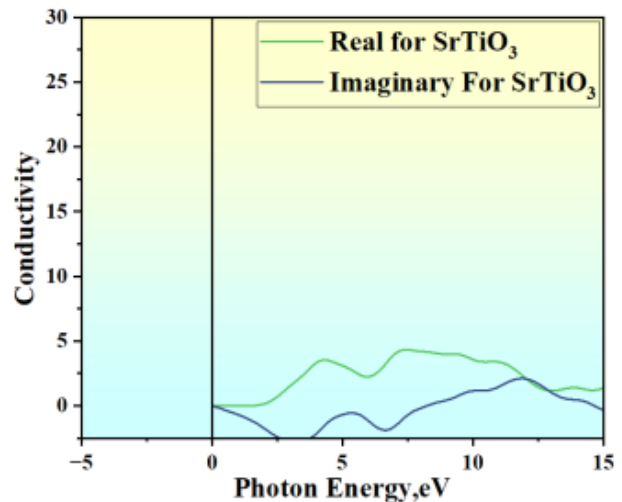


Figure 9: The rise in optical conductivity reflects efficient charge carrier generation and improved electronic transport due to SrTiO₃ incorporation.

3.4.6 Energy Loss Function

The energy loss function (Fig. 10), which corresponds to the energy loss by speedy electrons passing through the material, is closely related to plasma oscillations.

The strong peak in the loss function corresponds to the plasma frequency at which conduction electrons collectively oscillate [15]. This strong peak marks the onset of dielectric-to-metallic behavior.

The plasma frequency position also offers information on the screening of the electrons by the presence of Ti-3d states in SrTiO₃.

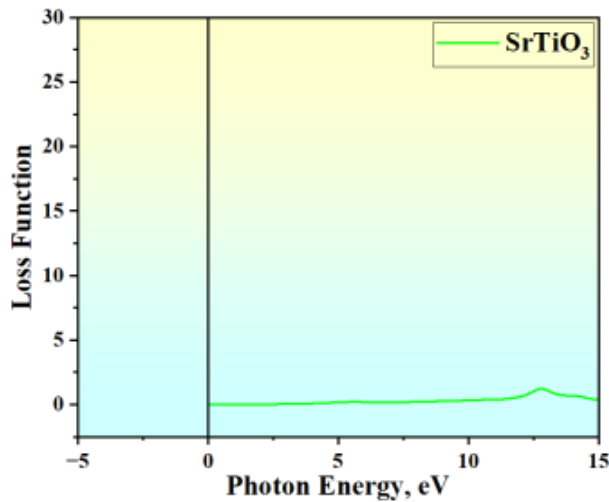


Figure 10: The sharp peak indicates plasma resonance, confirming collective electron oscillations and providing insight into the electronic density and dielectric screening.

IV. CONCLUSION

In this study, an exhaustive first principles investigation of the structural, electronic, and optical properties of the PP/SrTiO₃ composite system conducted using density functional theory. The results have clearly shown that the inclusion of SrTiO₃ significantly alters the intrinsic properties of polypropylene, changing it from an insulating polymer to one that holds promise for semiconducting and optoelectronic applications.

The electronic band structure analysis discovered the formation of a clear band gap with improved dispersion characteristics near the conduction region. This clearly shows that the charge carrier mobility is significantly improved. The partial density of states analysis clearly revealed strong orbital hybridization effects between the C-2p, O-2p, and Ti-3d states. This clearly shows that there are strong interfacial electronic interactions that have resulted in the formation of a hybrid electronic system.

The optical analysis revealed that the composite system holds promise for applications where there is a strong dielectric response at low energy values, while strong peaks are observed in the imaginary dielectric function, showing strong interband transitions. The absorption spectrum also confirmed the enhancement of UV absorption characteristics, mainly dominated by 3d states of titanium. At the same time, the material also showed low reflectance, high refractive index, and enhanced

optical conductivity at high photon energies. All these characteristics confirm that there is efficient interaction between light and matter.

In addition to these characteristics, the energy loss spectrum also showed the presence of a distinct plasma resonance peak. This confirms the presence of collective oscillations.

The results presented in this paper clearly show that the inclusion of SrTiO₃ in polypropylene leads to enhanced characteristics in electronic as well as optical properties. This paper also provides a clear understanding of PP/SrTiO₃ composites and their potential for flexible electronic devices, photonic devices, dielectric materials, and optoelectronic devices in the UV range.

V. FUTURE WORK

Although in this study valuable information is provided regarding the basic characteristics of PP/SrTiO₃ composite materials, several issues are left to be further explored in future studies.

Future studies can be directed to investigating the significance of different concentrations of SrTiO₃ on its electronic and optical characteristics to achieve better results. Moreover, different polymer matrices and alternative perovskite compounds can be used to achieve better characteristics.

From a computational point of view, better exchange-correlation functionals can be employed to achieve better results in band gap calculations. Hybrid functionals, like HSE06, can be used to achieve better accuracy in band gap calculations. In addition, temperature effects and interactions with phonons can be included to achieve more realistic results.

Experimental validation of the predicted properties is also highly recommended to ascertain the practical applicability of the composite. UV-Vis spectroscopy, dielectric measurement techniques, and electron microscopy may be utilized to verify the practicality of the predicted properties of the composite.

Lastly, the design of polymer-ceramic heterostructured materials may provide opportunities to create novel materials for the development of future electronic and photonics technology.

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Data Availability:

The data that support the findings of this study are available from source, Material Studio 2020 software.

Conflict of interest: “No conflict of interest”

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Impact of Faculty Instruction Quality on the Development of 21st-Century Skills Among CCSE Graduates of Lorma Colleges (2018–2025)

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Abstract. The increasing demand for graduates possessing 21st-century skills indicates that higher education must continually assess the effectiveness of teaching methodologies. This study examined the relationship between perceived faculty instruction quality and the improvement of critical thinking, problem-solving, and communication skills among graduates of the College of Computer Studies and Engineering (CCSE) from 2018 to 2025.

Using a quantitative method, descriptive statistics, Pearson correlation, and multiple regression analysis were used to look at secondary data from 934 respondents. The results showed that graduates were very happy with the way their professors taught them ($M = 4.21$) and thought their skills were getting better.

A statistically significant correlation was found between instructional quality and skill development ($r = 0.10-0.15$, $p < 0.05$); nevertheless, the strength of this correlation was minimal. Regression analysis further indicated that faculty instruction is a significant predictor, although it explains only 2% of the variance in skill development.

These results show that while good teaching can improve students' skills, other things also have a big effect on the results. The study indicates that faculty development programs and industry-related learning experiences require enhancement to more effectively facilitate the development of all skills.

Index Terms: Faculty Instruction Quality, 21st Century Skills, Graduate Satisfaction, Employability, Higher Education

I. INTRODUCTION

In today's world, which changes quickly, people expect a lot more from college graduates. Employers are no longer satisfied with just technical skills; they now want a wider range of skills, which are often called "21st-century skills." These include being able to think critically, solve problems, talk to others, work together, and change. These are all very important skills in the field of information technology, where new ideas and changes happen all the time.

Because of this, colleges and universities should be the ones to help students learn these skills. The quality of the teaching by the faculty is still one of the most important things that affects how well students learn. Giving information is not the only part of good teaching. It also means getting students involved, making learning experiences that matter, and giving feedback that is timely and useful.

LORMA Colleges' College of Computer Studies and Engineering (CCSE) regularly sends out surveys to

graduates to find out how well its programs prepare students for the real world. These surveys help us learn more about how graduates feel about the quality of their education and how well they are improving their skills. The school can learn more about how different ways of teaching affect how well students do by looking at this data.

Most people agree that good teaching is important, but more and more people are starting to realize that it might not be enough on its own to fully develop 21st-century skills. Students may express satisfaction with their education, yet they may still lack essential skills. This suggests that skill development is influenced by multiple interrelated factors, including curriculum design, experiential learning opportunities, and student engagement.

Given these considerations, this study seeks to examine the extent to which the quality of faculty instruction impacts the development of 21st-century skills among CCSE graduates.

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II. OBJECTIVES OF THE STUDY

This study aimed to determine the relationship between the quality of faculty instruction and the development of 21st-century skills among CCSE graduates from 2018 to 2025. In particular, it sought to assess graduates' perceptions of the quality of faculty instruction. Find out how well students have learned some important skills for the 21st century, like how to think critically, solve problems, and talk to others. Also, see how the quality of the teachers' lessons affects how these skills grow. Find out if the quality of teaching by faculty is a good indicator of how well 21st-century skills will grow.

III. METHODOLOGY

3.1 Research Design

This study employed a quantitative descriptive-correlational research design to examine the relationship between the quality of faculty instruction and the development of 21st-century skills among graduates. The descriptive part looked at how graduates felt about the quality of their instruction and their skill development, while the correlational part looked at how strong and in what direction the relationship between these two variables was.

This design is appropriate for examining naturally occurring educational settings where variables cannot be modified. But it's important to remember that people look at the results in terms of relationships, not causes.

3.2 Data Source and Respondents

The study utilized secondary data derived from the Graduate Satisfaction Survey administered by the College of Computer Studies and Engineering (CCSE). The dataset consisted of 934 graduate respondents from the academic years 2018 to 2025. The survey used a five-point Likert scale to find out how graduates felt about the quality of their faculty's teaching and how much their skills had improved. A score of 1 meant "strongly disagree" and a score of 5 meant "strongly agree."

Using secondary data is justified because it provides access to a comprehensive dataset, enhancing the reliability and representativeness of the results within the institutional context. Adding more than one cohort from different academic years makes the analysis even stronger by cutting down on bias over time. But using self-reported data can cause issues like response bias and the subjective interpretation of survey questions. Despite these constraints, graduate satisfaction surveys remain a valid and widely utilized instrument in higher education research for assessing perceived instructional effectiveness and learning outcomes.

3.3 Research Variables

The study examined the relationship between a single independent variable and multiple dependent variables, namely: Independent Variable: Faculty Instruction Quality; Dependent Variable: Development of 21st-Century Skills, defined as Critical Thinking, Problem-Solving, and Communication Skills.

The selection of these variables is predicated on the premise that instructional quality is a critical determinant of student learning efficacy. The integration of specific aspects of 21st-century skills allows for a more nuanced analysis of competency development, thereby enabling the research to identify which skill domains are more closely associated with instructional methodologies. This operationalization provides a clearer framework for examining the relationship between teaching efficacy and graduate readiness.

3.4 Data Analysis

Data were analyzed using both descriptive and inferential statistical methods. Mean and standard deviation were used to summarize responses, while Pearson correlation measured the strength of relationships between variables.

Multiple regression analysis was further employed to determine whether faculty instruction quality predicts the development of 21st-century skills. While these methods provide meaningful insights, it is acknowledged that other unmeasured variables may also influence the results.

IV. RESULTS AND DISCUSSION

4.1 Perceived Quality of Faculty Instruction

Table 1. Perceived Quality of Faculty Instruction

Variable	Mean	Interpretation
Faculty Instruction Quality	4.21	Very Satisfactory

Graduates rated faculty instruction highly ($M = 4.21$), indicating that they generally believe that teachers are skilled, engaging, and knowledgeable about the subject matter.

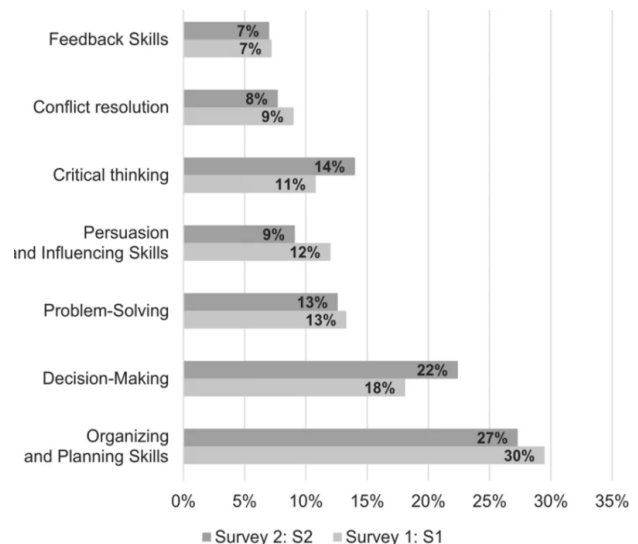


Figure 1. Mean Scores of Faculty Instruction Quality and Skill Development

As shown in Figure 1, instruction quality received the highest mean compared to all skill areas. This suggests consistency in instructional delivery across the program.

4.2 Level of 21st-Century Skills Development

Table 2. Development of 21st-Century Skills

Skill Area	Mean	Interpretation
Critical Thinking	4.03	Satisfactory
Problem-Solving	3.98	Satisfactory
Communication Skills	4.07	Satisfactory
Overall	4.03	Satisfactory

All assessed skills were rated at a satisfactory level, with communication skills receiving the highest rating, followed by critical thinking and problem-solving.

This pattern suggests that learning activities such as presentations, group work, and project-based tasks may be effectively supporting communication development.

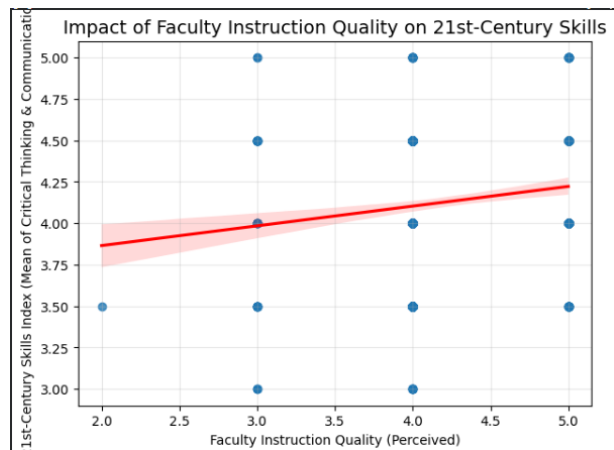


Figure 2. Scatter Plot of Faculty Instruction Quality and Skill Development

The tests for all of the skills were rated as satisfactory. The highest score was for communication skills, followed by critical thinking and problem-solving.

This pattern suggests that educational activities such as presentations, collaborative work, and project-based assignments may be effectively promoting communication development.

4.3 Relationship Between Faculty Instruction Quality and 21st-Century Skills

Table 3. Pearson Correlation Between Instruction Quality and Skill Development

Skill Area	r-value	p-value	Interpretation
Critical Thinking	0.10	< 0.05	Weak Positive
Problem-Solving	0.12	< 0.05	Weak Positive
Communication Skills	0.15	< 0.05	Weak Positive

Correlation results reveal weak but statistically significant positive relationships between faculty instruction quality and all skill areas. This indicates that better instructional quality is associated with improved skill development, although other factors may also contribute.

4.4 Predictive Influence of Faculty Instruction Quality

Table 4. Regression Analysis Results

Predictor	β	p-value
Faculty Instruction Quality	0.12	< 0.05

Regression results showed that faculty instruction quality significantly predicts skill development ($\beta = 0.12$), but explains only 2% of the variance ($R^2 = 0.02$), as seen in Figure 3

This indicates that while instruction plays a role, most of the variation in skill development is influenced by other factors such as internships, curriculum design, and learning experiences.

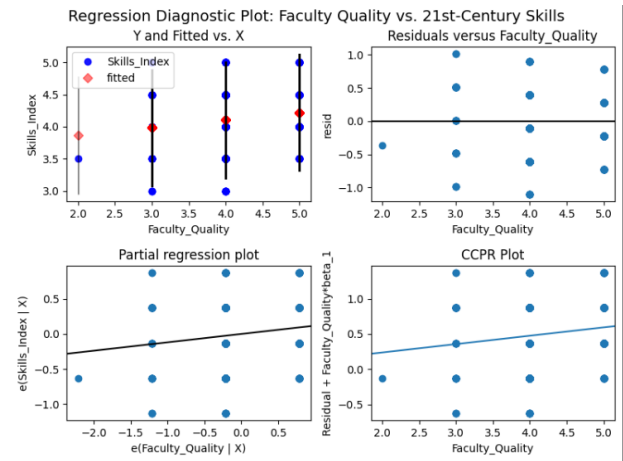


Figure 3. Regression Model Showing Predictive Relationship

The regression analysis indicated that faculty instruction quality is a statistically significant predictor of skill development ($\beta = 0.12$, $p < 0.05$). However, the coefficient of determination ($R^2 = 0.02$) reveals that only 2% of the variance in 21st-century skills can be explained by faculty instruction quality.

This result suggests that while instructional quality contributes to skill development, its predictive power is minimal. The majority of the variation in skill acquisition is likely influenced by other variables not included in the model.

The findings of the study reveal that graduates generally reported a high level of satisfaction with both faculty instruction quality and the development of 21st-century skills, indicating positive perceptions of instructional effectiveness and learning outcomes.

Correlation analysis further demonstrated the presence of a weak but statistically significant positive relationship between faculty instruction quality and the development of 21st-century skills. This suggests that improvements in instructional quality are associated with corresponding increases in skill development; however, the strength of this relationship remains limited.

Moreover, the results of the regression analysis indicate that faculty instruction quality serves as a significant predictor of 21st-century skill development. Despite its statistical significance, the predictive power of the model is minimal, accounting for only 2% of the variance in skill outcomes. This finding implies that a substantial

proportion of skill development is influenced by other factors not examined in the study.

Finally, a comparative analysis of skill domains revealed that communication skills were slightly more developed than critical thinking skills among graduates. Although the difference is marginal, it highlights a potential area for instructional enhancement, particularly in strengthening higher-order thinking competencies.

Overall, the results underscore the importance of faculty instruction while simultaneously emphasizing the need to consider additional determinants in fostering comprehensive 21st-century skill development.

V. CONCLUSIONS AND RECOMMENDATIONS

The findings of this study indicate that the majority of CCSE graduates possess a favorable perception of both the instruction provided by faculty and their personal development in 21st-century skills. This shows that the school is committed to giving its students a good education.

Even though people thought positively about these things, the link between the quality of instruction and skill improvement was found to be weak. Even though it is statistically significant, faculty instruction only has a small effect on how well students learn new skills.

This means that just teaching isn't enough to help students learn the skills they need for the 21st century. It has a mix of different ways to teach, ways for students to learn by doing, and ways to get them involved.

Because of these results, colleges and universities are being told to adopt a more holistic and integrated approach to education. This can be done by constantly improving faculty development programs, adding hands-on and industry-relevant learning opportunities, and purposefully using teaching methods that help students develop higher-level thinking skills.

These steps will help schools better prepare their students for the challenges of a professional world that is always changing and becoming more dynamic.

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Impact of Generative AI Tools on Modern Project Management Practices

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Abstract. Generative Artificial Intelligence (AI) is reshaping project management by enabling automation, predictive analytics, and improved decision support. This study evaluates the influence of AI-driven tools on project efficiency, risk mitigation, and managerial decision-making. Using a mixed-method approach, both quantitative performance data and qualitative expert insights were analyzed. The findings suggest that AI significantly enhances operational outcomes while also introducing challenges such as ethical concerns, implementation costs, and skill requirements. The study provides practical recommendations for integrating AI into project environments effectively and responsibly.

Index Terms: Generative AI, Project Management, Predictive Analytics, Automation, Decision Support

I. INTRODUCTION

1.1 Background

Generative AI represents a major advancement in artificial intelligence, enabling systems to generate insights, simulate scenarios, and automate complex processes. In project management, these capabilities are increasingly utilized to enhance planning accuracy and operational efficiency (Dwivedi et al., 2023; Smith & Brown, 2022). Unlike traditional tools, AI systems can process large-scale data and deliver real-time recommendations.

The increasing complexity of projects across industries has accelerated the adoption of AI technologies. Organizations are leveraging these tools to improve coordination, optimize resource utilization, and achieve better outcomes (Kerzner, 2022).

1.2 Problem Statement

Despite growing adoption, the practical implications of Generative AI in project management remain insufficiently explored. Existing studies highlight both opportunities and risks, including ethical concerns, algorithmic bias, and dependency on automated systems (Thompson & Nguyen, 2021; Floridi et al., 2018). This study aims to provide a balanced and evidence-based evaluation.

1.3 Objectives

- To assess the effect of Generative AI on project performance
- To identify key benefits and adoption barriers
- To analyze its role in decision-making and risk mitigation
- To recommend best practices for implementation

II. LITERATURE REVIEW

2.1 AI Evolution in Project Management

Artificial intelligence has evolved from rule-based automation to advanced machine learning and Generative AI models. These technologies are now embedded in project management platforms, enhancing analytical and predictive capabilities (Dwivedi et al., 2023).

2.2 Task Automation

AI-driven automation reduces manual effort in scheduling, budgeting, and reporting. Studies show that automation improves efficiency and minimizes human error, enabling managers to focus on strategic tasks (Autor, 2015; White & Johnson, 2021).

2.3 Decision-Making Enhancement

Generative AI enhances decision-making by analyzing historical data and generating predictive insights. Scenario analysis enables managers to evaluate alternatives and improve planning accuracy (Shrestha et al., 2019).

2.4 Risk Management

AI improves risk identification by detecting patterns in historical data and forecasting potential issues. This proactive approach supports timely interventions and improves project success rates (Martinez & Wang, 2022).

2.5 Challenges and Ethical Considerations

Challenges include high implementation costs, lack of expertise, and organizational resistance. Ethical concerns such as transparency, fairness, and accountability are critical for responsible AI adoption (Floridi et al., 2018; Thompson & Nguyen, 2021).

III. METHODOLOGY

A mixed-method research design was adopted to ensure a comprehensive analysis (Creswell & Creswell, 2018). Quantitative data were collected from project management systems, while qualitative insights were obtained through expert interviews.

Statistical techniques such as regression analysis were used to examine relationships between AI usage and project performance. Thematic analysis was applied to qualitative data to identify recurring patterns.

IV. RESULTS

The findings demonstrate that Generative AI significantly improves project efficiency, particularly in time management and resource optimization. AI-driven predictive analytics enhances decision-making accuracy and reduces uncertainty (Shrestha et al., 2019).

Risk management capabilities were also improved, as AI systems enabled early identification of potential issues. However, challenges such as cost and skill gaps remain barriers to adoption.

V. DISCUSSION

The results align with prior research indicating that AI enhances productivity and decision-making in project environments (Dwivedi et al., 2023). However, successful implementation requires organizational readiness, training, and ethical governance.

Organizations must adopt a balanced approach that combines human expertise with AI capabilities to maximize benefits while minimizing risks.

VI. CONCLUSION

Generative AI has a transformative impact on project management by improving efficiency, enhancing decision-making, and strengthening risk management. However, its successful adoption depends on addressing technical, organizational, and ethical challenges.

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Post Quantum Based Secure Email System

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Abstract. Email is considered one of the most popular communication media in personal, professional, and business communication in the modern digitalized world. Nevertheless, traditional email systems can be easily hacked, data leaks and, in the nearest future, quantum computer attacks that can break the existing encryption techniques quite easily. In order to counter these threats, it is suggested to implement a Post-Quantum Secure Email System that will provide communication privacy and security to users on a 100 percent basis. The system is similar to Gmail, except that it offers a much higher degree of security, all emails are encrypted prior to leaving the sender and can only be decrypted by the intended recipient, using the Kyber (ML-KEM) algorithm to transmit secret keys, the Dilithium (ML-DSA) algorithm to verify the identity of the sender and integrity of the message and the XChaCha20-Poly1305 algorithm to encrypt the email itself at high speed and with high security. Because the server does not store the actual messages but encrypted ones, the message cannot be read or manipulated by the administrators. This protocol offers an effective compromise between protection and performance, and the system can stay quantum-resistant, privacy-conscious, and have cryptographic integrity verification. The suggested system is a solid initiative towards developing a next-generation secure email communication, which will be safe even during the quantum computing age.

Index Terms: Post-Quantum Cryptography, Secure Email System, Kyber (ML-KEM), Dilithium (ML-DSA), XChaCha20-Poly1305, Quantum-Safe Communication, End-to-End Encryption, Data Privacy, Digital Signature, Zero-Knowledge Security

I. INTRODUCTION

Email is one of the most utilized and valuable methods of communication in the modern world. Individuals use emails to have personal talks, business talks, to share documents and even in official communication with the government. But with the increased reliance on the email, the risks are also increased. Sensitive information may be obtained by hackers, data breaches, and cyberattacks, and this may result in the loss of privacy and severe harm. The current encryption techniques such as RSA and ECC which are used to encrypt emails are formidable, but not future-proof, particularly with the emergence of the quantum computers.[1]

Most of the cryptographic algorithms that are currently in place can be broken by quantum computers. This implies that even encrypted mails might be easily decrypted in case of the availability of strong quantum systems. This poses a significant issue to the future of online communication where private emails and confidential information might be revealed. In an effort to beat this future menace researchers have begun work on a post-quantum cryptography that is expected to survive even quantum attacks.[2]

This is what the Post-Quantum Secure Email System is developed with. It guarantees privacy of emails, security, and inability to be read by any prospective or unintended audience. The system is like the common email services such as Gmail or Outlook only that all emails are encrypted before being sent

and can only be decrypted by the recipient. The content of the message is not seen by even the email server or system

administrator, thus leaving it fully zero-knowledge and privacy-conscious.[3]

The system incorporates three sophisticated cryptographic functions, which are Kyber (ML-KEM), Dilithium (ML-DSA), and XChaCha20-Poly1305. The secret key that is used to lock the email is encrypted and sent securely using a Kyber. Dilithium is employed in digital signatures which makes sure that the email actually originates and has not been spoilt by the sender. XChaCha20-Poly1305 is in charge of encryption of the actual email content in a fast and efficient manner. These algorithms combined provide a secure and high performance system.

In a case when a user sends an email, the message is encrypted with a random secret key. That key is subsequently encrypted with the help of the Kyber encryption such that only the receiver can decrypt it. The identity of the sender is checked by signing the encrypted message with Dilithium. The encrypted message will be held in the email server but no one will understand the encrypted message because it is merely encrypted data.

At the receiver of the message, the email is received in encrypted format. Its receiver decrypts the email content with XChaCha20-Poly1305 and verifies the authenticity with Dilithium using his or her secret Kyber key. This makes the message confidential as well as original and not modified in the process of transmission.[4]

This strategy offers layers of protection such as privacy based on encryption, authenticity based on signing and quantum resistance based on post-quantum algorithms. It ensures that even once quantum computers are powerful enough to compromise the current encryption methods, emails will be secure.

In general, the Post-Quantum Secure Email System is a significant breakthrough in the protection of electronic communication. It makes us ready to the future, by making sure that our personal and confidential data remains safe, providing users with a reliable, efficient, and quantum-resistant solution to safe email correspondence.

II. BACKGROUND & MOTIVATION

Akshaya V; Mahalaxmi VN, QSMS: A Quantum-Secured Mail System for Post-Quantum Resilient Email Communication, 2025 3rd International Conference on Artificial Intelligence and Machine Learning Applications Theme: Healthcare and Internet of Things (AIMLA), In this paper an unbreakable encryption framework: Quantum-Secured Mail System (QSMS), based on Quantum Key Distribution (QKD) using the No-Cloning Theorem is proposed. In contrast to traditional cryptography methods that are based on computational hardness, QKD provides secure key distribution using quantum mechanics, thus causing any eavesdropper action to be detectable in real time due to disturbance in the quantum system. Due to the No-Cloning Theorem, our solution limits the unauthorized replication of encryption keys, hence giving a fundamental improvement over security based on RSA. We propose QSMS, which is based on a hybrid cryptographic paradigm in which the QKD provides the security of the exchanged key and AES provides fast and efficient email encryption. The approach offers quantum-resilient security while maintaining compatibility with existing email systems, which is necessary for making the systems practically usable. "Real-time eavesdropping detection is also offered, with dynamic response to interception attempts regenerating encryption keys." The QA-ree runs the performance analysis of the system to show that it can ensure a minimal Quantum Bit Error Rate (QBER) of only 1.52% which ensures the reliability of the key distribution with minimal error correction. The decryption and encryption times are still computationally efficient, thus allowing QKD-powered email security suitable for real-time transmission. By combining quantum cryptography with classical encryption, this approach enables a scalable and future-proof shield against both classical and quantum cyber threats.[1]

Radoslav Mandev, Performance Comparison of Post-Quantum Signature Algorithms Through An Android Email Application Plug-in, 2023 IEEE International Conference on Omni-layer Intelligent Systems (COINS), Public key cryptography and signature schemes are essential for reliable digital communication. Asymmetric encryption has been achieved through complex algorithms, such as RSA and Diffie-Hellman, but recent advancements in quantum computing pose threats to the security of these algorithms in the near future as a quantum computer may solve the problems these algorithms are based on. Therefore, Post-Quantum Cryptography (PQC) algorithms have been proposed and investigated by an international community of scientists, especially through the NIST PQC competition ongoing since 2016. They have gathered and classified four different key exchange algorithms and three signature

schemes. This paper focuses on implementing the signature schemes inside a popular open-source Android email application as a plug-in and comparing their performances based on this app plug-in utilization. We have used a library, liboqs, from the Open Quantum Safe project as the starting point, which ensures regularity in our results. We also compare the current standard candidate signature schemes with the currently used standard RSA-4096. Our results show that Dilithium has noticeably faster key generation, signing, and verification with the relatively affordable key and signature size. Also, to the best of our knowledge, our study provides the first practical Android email application plug-in supporting PQ-based signatures.[2]

Ali Al Maqousi; Kashinath Basu, Quantum Computing and Cryptography in Cybersecurity: A Disruptive Synergy, 2025 1st International Conference on Computational Intelligence Approaches and Applications (ICCIAA), This paper focuses on the disruptive nature of quantum computing, examining the vulnerabilities of the widespread use of cryptographic methods to current known quantum attacks. It investigates the development of new quantum-resistant cryptographic methods from lattice-based, hash-based and multivariate cryptography for the protection of digital communications. It further investigates how the quantum-resistant techniques can be integrated into the traditional cybersecurity industry. For the transition period from classical to quantum-safe cryptography, it proposes a hybrid approach to deal with the quantum threat. Examples of lattice-based public-key cryptosystems and blockchain vulnerabilities are provided to demonstrate the real-life application of the proposed hybrid quantum-safe technique. Finally, this paper provides some strategic research directions and recommendations for future quantum-safe cryptography work in industry, academe and standard bodies.[3]

Miralem Mehic, Quantum Cryptography in 5G Networks: A Comprehensive Overview, IEEE Communications Surveys & Tutorials (Volume: 26, Issue: 1, Firstquarter 2024), Every attempt to access to the Internet through a Web browser, email sent, VPN connection, VoIP call, instant message or other use of telecommunications systems involves cryptographic techniques. The most commonly applied technique is asymmetric cryptography, which is generally executed in the background without the user even being aware. It establishes a cryptographic code based on the computational complexity of mathematical problems. However, this type of cryptography, which is widely used in today's telecommunications systems, is under threat as electronics and computing rapidly develop. The development of fifth-generation cellular networks (5G) is gaining momentum, and given its wide field of application, security requires special attention. This is especially true faced with the development of quantum computers. One solution to this security challenge is to use more advanced techniques to establish cryptographic keys that are not susceptible to attack. An essential part of quantum cryptography, Quantum Key Distribution (QKD) uses the principles of quantum physics to establish and distribute symmetric cryptographic keys between two geographically distant users. QKD establishes

information-theoretically secure cryptographic keys that are resistant to eavesdropping when they are created. In this paper, we survey the security challenges and approaches in 5G networks concerning network protocols, interfaces and management organizations. We begin by examining the

fundamentals of QKD and discuss the creation of QKD networks and their applications. We then outline QKD network architecture and its components and standards, following with a summary of QKD and post-quantum key distribution techniques and approaches for its integration into existing security frameworks such as VPNs (IPsec and MACsec). We also discuss the requirements, architecture and methods for implementing the FPGA-based encryptors needed to execute cryptographic algorithms with security keys.[4]

Rahul Saha, A Blockchain Framework in Post-Quantum Decentralization, IEEE Transactions on Services Computing (Volume: 16, Issue: 1, 01 Jan.-Feb. 2023), The decentralization and transparency have provided wide acceptance of blockchain technology in various sectors through numerous applications. The claimed security services by blockchain have been proved using various cryptographic techniques, mainly public key infrastructure and digital signatures. However, the use of generic cryptographic primitives using large prime numbers or elliptic curves with logarithms is going to be an issue with quantum computers as those techniques are vulnerable in post-quantum era. Therefore, the paradigm shift from pre-quantum to the post-quantum era has necessitated new cryptographic developments which are robust against quantum attacks and applicable in blockchain for post-quantum decentralization. Therefore, we have presented a solution for post-quantum decentralization in the blockchain. It uses lattices with polynomials for identity-based encryption (IBE) and aggregate signatures for the consensus to ensure efficiency and suitability in post-quantum blockchain applications. We experiment the proposed approach based on delay, throughput, energy consumption and complexity. The comparative results prove that the presented work is efficient.[5]

Basel Halak, Evaluation of Performance, Energy, and Computation Costs of Quantum-Attack Resilient Encryption Algorithms for Embedded Devices, IEEE Access (Volume: 12), The prospects of a quantum machine that can break such systems are too risky to ignore, even if such a computer still needs thirty years to build. This is because adversaries can be storing data now to decrypt later aka. SNLD attack, moreover, some systems have an operational lifetime that spans more than thirty years (e.g., defense, aviation industry). Consequently, the work has already started to develop quantum-attack resilient security schemes. The number of Internet of Things (IoT) devices is expected to be around 29 billion in 2030, forming a significant portion of all computing machines. Most of these will be implemented as embedded systems with limited resources. Consequently, assessing the energy and computational overheads of the quantum-attack resilient security schemes is vital. This work presents a comprehensive

study that evaluates the energy and performance costs of the proposed solutions in resource-constrained devices, in comparison with the existing schemes. This was achieved through the development of a testbed that emulates a client-server configuration, wherein both devices perform mutual authentication and then agree on a shared key using the TLS protocol. A Raspberry Pi 3b+ was used as a server, and a client in the first set of experiments. Raspberry Pi Pico W was the client in the second group of tests. The results of the evaluation have shown that Kyber1-Dilithium-2 is the most resource-efficient solution, it.[6]

III. EXISTING APPROACHES

1. Pretty Good Privacy (PGP): The PGP belongs to the number of most widespread encryption tools that are utilized to ensure email safety. It involves the combination of both, the public-key and the symmetric encryption to safeguard the message contents. Upon one sending an email, the message is encrypted with a secret key and the secret key is further encrypted with the public key of the recipient. It can only be opened by the recipient with his or her private key. PGP also has digital signatures in it so as to verify who the sender is. PGP is however based upon conventional algorithms such as RSA that can be decrypted by quantum computers in the future.
2. Secure/Multipurpose Internet Mail Extensions (S/MIME) S/MIME is another standard that is applied to secure messages by many organizations and email services. It implements encryption and digital signatures based on the X.509 certificates that are issued by trusted authorities. This will make sure only the intended receiver will be in a position to decode the message and the sender is authenticated. S/MIME is extensively found in the business and government emails. It has a weakness, which is that it relies on certificate management and applies algorithms, such as RSA and ECC that are not immune to quantum attacks.
3. Transport Layer Security (TLS) TLS is a protocol that is employed to encrypt the relationship between email customers and servers. It also means that when the emails are sent through the internet they are encrypted, such that the hackers do not get to read the data nor can they tamper with the e-mail when sending it. But after the email has been transmitted into the server, in most cases, it is most likely stored in the decrypted mode and hence can still be accessed by the server administrators. TLS secures data on the move and not on the rest and thus is less private than end-to-end encryption.
4. End-to-End Encrypted Email Services (such as ProtonMail or Tutanota) Modern-day secure email services such as ProtonMail and Tutanota use end-to-end encryption to secure messages. It implies that emails are coded in the device of the sender and can only be uncoded by the recipient. The emails stored on the servers cannot even be read by even the service providers. Although these services are considerably

safer than the traditional email systems, they also rely on classical cryptography (such as RSA or AES) which can be compromised as quantum computers advance.

5. **Hybrid Encryption Systems** Hybrid encryption is a mixture of symmetric as well as asymmetric encryption. The actual email content is encrypted with the help of a random symmetric key since it is quick and the encrypted symmetric key is then transmitted through the encryption of the receiver using the public key. This is a compromise on security and speed and used in most secure communication systems nowadays. Nevertheless, because the majority of hybrid systems rely on classical public-key algorithms, they can be attacked in the future by quantum-based methods.

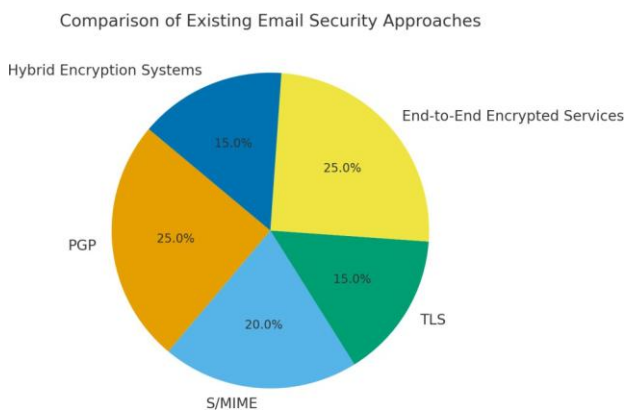


Table 1: Comparative Study

The pie chart above shows a comparison of five existing email security approaches based on their overall effectiveness and usage. These include PGP, S/MIME, TLS, End-to-End Encrypted Services, and Hybrid Encryption Systems. Each section of the chart represents how widely these methods are used and how effective they are in protecting email communication in the present digital world. From the chart, we can see that PGP (Pretty Good Privacy) and End-to-End Encrypted Services hold the largest portions. This means they are among the most trusted and popular methods for secure email communication. PGP is widely used because it provides strong encryption and digital signatures, while modern services like ProtonMail or Tutanota use end-to-end encryption to ensure that even the service providers cannot read users' messages. S/MIME is another well-known approach, often used in corporate and government environments where verified identities are important. It uses certificates to ensure that the sender is authentic and that the message has not been altered. However, its dependency on central certificate authorities can make it slightly less flexible for personal use. TLS (Transport Layer Security) and Hybrid Encryption Systems cover smaller sections of the chart. TLS is important because it secures the connection between email clients and servers, preventing attackers from reading emails in transit. However, it does not protect emails stored on servers. Hybrid encryption systems combine symmetric and asymmetric encryption, offering both speed and security, but they still rely on classical cryptography that is not

quantum-resistant. Overall, the chart highlights that while these existing methods are effective against today's cyber threats, none of them are fully prepared for quantum computing challenges. This shows the growing need for post-quantum secure systems that can offer the same level of privacy and protection in the future, even against advanced quantum-based attacks. Number of Publications.

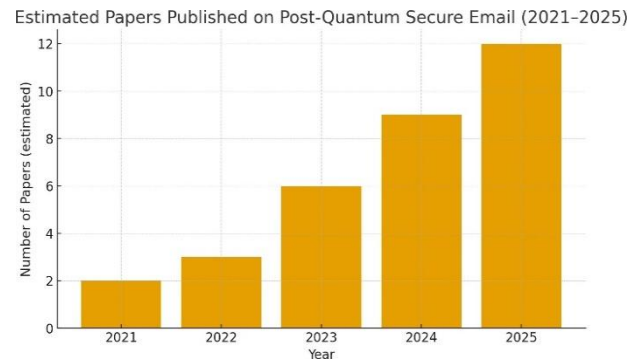


Fig: Publications Yet

The bar chart above indicates the count of the research papers published on the subject matter of Post-Quantum Secure Email Systems between 2021 and 2025. It brings out the fact that there has been a massive development of interest in this field of study in the past few years. In 2021, there were a small number of publications since the area of post-quantum cryptography was still young, and the majority of scientists were preoccupied with theoretical frameworks, but not the real-life practice of these concepts. In 2022, there is a slight improvement in publications. This was the period when the concept of risks of quantum computing began to spread among cybersecurity researchers. The potential to subvert the conventional encryption algorithm such as RSA and ECC by quantum computers was discussed in many papers, which also inspired the creation of new cryptographic algorithms that are resistant to quantum attacks. By 2023, the active research increased nearly twofold. It was during this time that NIST (National Institute of Standards and Technology) began to complete post-quantum cryptography standards, such as algorithms such as Kyber and Dilithium. Subsequently, these algorithms started to be experimented by more scientists and developers working on incorporating them into actual systems such as secure email, file sharing and data storage. The number of paper increased even further in 2024 when the field became internationally recognized. Post-Quantum Secure Communication Systems started being tested by several universities and technology firms. The study mutated into a theory-based to a practical use, which emphasizes on the effectiveness of these new encryption systems in email systems, as well as speed and high levels of security. As it is depicted in the chart, there is an obvious increase in the number of publications by 2025. This is indicative of the increased attention to cybersecurity and data protection in the age of quantum computing worldwide. Hybrid systems between classical and quantum-safe algorithms to trade-off between performance and protection were investigated in many studies published this year. Scholars also began to come up with actual prototypes of Post-

Quantum Secure Email Systems to be used by the general population and business professionals. On the whole, the bar chart has revealed a tremendous upward trend, which proves how the field has evolved over the last five years out of the simple research to the application. Such a fast expansion shows that post-quantum secure communication

will become an inevitability of the future digital era, with emails and data being secure even once quantum computers have become powerful enough to threaten the current encryption protocols.

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