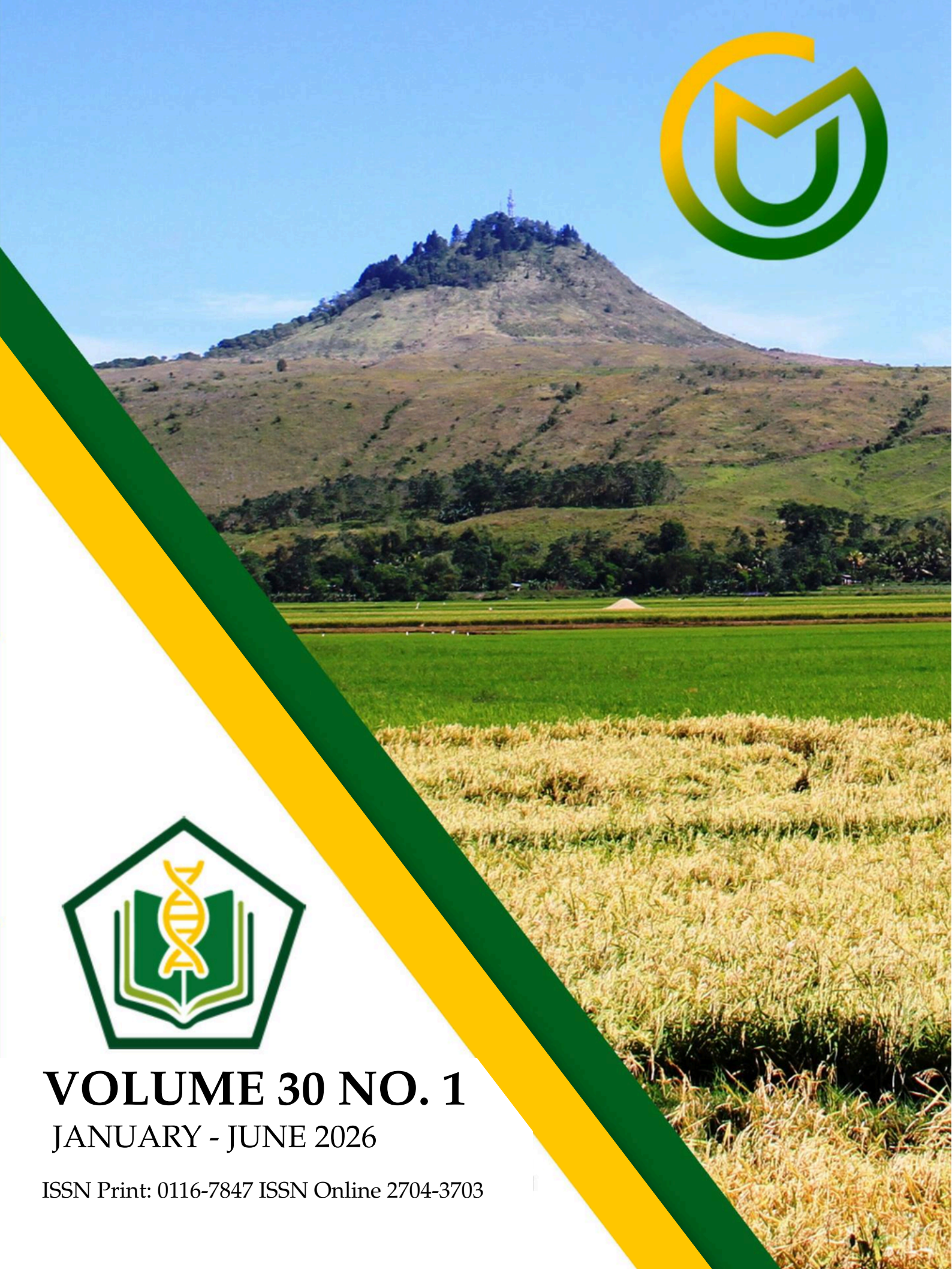


VOLUME 30 NO. 1

JANUARY - JUNE 2026

ISSN Print: 0116-7847 ISSN Online 2704-3703

table of

content

Volume 30 No. 1

Research Articles

5 **Self-Assessment of Social Communication Skills: Insights into Verbal, Non-Verbal, and Listening Aspects**
Kaisheng Wang, Maria Cecilia C. Ycong

18 **Exploring the Factors that Influence Students' Decision in Choosing their Accommodation: A Case in the University of Science and Technology of Southern Philippines - CDO**
Archemedes Wabe, Gerrich Aldin Babanto

40 **"Vaklang TWAH": Homosexuality in Honorio Bartolome de Dios' Select Short Stories**
Von Daniel Plasencia

51 **Utilizing Strong-Alkalized Cocoa Bean Shell Powder as a Functional Cocoa Substitute in Chocolate Cupcakes**
Eliezer P. Valencia Jr., Argel A. Largado, John Joseph C. Menia, Romel M. Felismino, Katherine Anne T. Castillo-Israel, Sheba Mae M. Duque

63 **An Internet of Things-based Traffic Light Control System Utilizing Computer Vision for Real-time Traffic Density Calculation**
Josh Ivan M. Caramat, Princess Leila R. Ditchon, Julie Ann Lontoc, Ivan Neil B. Tapel

74 **Effect of Rice Hull Biochar as an Additive on the Shear Strength Parameters of Silty Sand**
Ron Gabriel O. Navarro, Juliah Cristine I. Julio, Patrick Adrian M. Salazar, Andre C. Cruz, Bien Dave B. Papasin

85 **The Removal of Ethics from Higher Education: A Critical Threat to the Philippine Educational System**
Givheart Dano

94 **Beta-Lactam- and Aminoglycoside-Resistant *Vibrio parahaemolyticus* in Marine Food Fish from Four Public Markets in Bukidnon Province,Philippines**
Johndel Remon, Zeus Elumba, Matilda Grace Cempron, Reggie Dela Cruz, Joliesa Mae Toledo

107 **Antimicrobial Resistance and Molecular Identification of Vibrio spp. in Shellfish at Major Public Wet Markets in Bukidnon, Philippines.**
Matilda Grace Cempron, Zeus S. Elumba, Johndel M. Remon, Joliesa Mae S. Toledo, Reggie Y. Dela Cruz

117 **Assessing Demand for a Graduate Nutrition and Dietetics Program in Northern Mindanao**
Allene Mae N. Marapao, Marivic B. Lazar, Rachelle Gaye B. Caiña

journal of science

Publication Board Members

ROLITO G. EBALLE, Ph.D.
University President
Chairperson

ALAN P. DARGANTES, Ph.D.
Vice Chairperson

EINSTINE M. OPISO, Ph.D.
Editor-in-Chief

JANET ALEXIS A. DE LOS SANTOS, Ph.D.
Associate Editor

MARK LLOYD G. DAPAR, Ph.D.
Managing Editor

Editorial Board Members

RICHARD C. ALORRO, Ph.D.
Engineering Sciences
Curtin University, Australia

ENGR. MA. BERNADETH LIM, Ph.D.
Department of Civil Engineering
College of Engineering and Agro-Industrial Technology
University of the Philippines Los Baños, Philippines

CONSTANCIO ASIS JR., Ph.D.
Soil Science & Plant Nutrition
Department of Industry, Tourism and Trade
Northern Territory, Australia

APRIL HARI WARDHANA, SKH., MSi., Ph.D.
Department of Parasitology
Indonesian Research Centre for Veterinary Science (IRCVS)
Indonesia

VICTOR B. AMOROSO, Ph.D.
Biology (Botany)
Central Mindanao University, Philippines

KATHERINE ANN T. CASTILLO-ISRAEL, Ph.D., PFT
Scientist, Food Science
Institute of Food Science and Technology
College of Agriculture and Food Science
University of the Philippines Los Baños, Philippines

DENIS A. TAN, Ph.D.
Mathematics Education
College of Education
Central Mindanao University, Philippines

DENNIS RELOJO-HOWELL, MSc, MBPsS
Psychological Sciences
Psychreg, United Kingdom

MICHAEL ARIEH P. MEDINA, Ph.D.
Environmental Science
Central Mindanao University, Philippines

CARLITO B. TABELIN, Ph.D.
Ceramic, Chemical & Metallurgical Engineering
Mindanao State University - IIT, Philippines

WILFREDO V. ALANGUI, Ph.D.
Department of Mathematics & Computer Science
University of the Philippines Baguio, Philippines

FROLAN A. AYA, Ph.D.
Scientist, Aquaculture Department
Southeast Asian Fisheries Development Center, Philippines

MARICAR AGUILOS, Ph.D.
Department of Forestry & Environmental Resources
North Carolina State University, United States of America

GUNAGAMBHIRE M. VIDYASAGAR, Ph.D.
Botany & Biotechnology
Gulbarga University, India

GIL P. SORIANO, PhD, MHPEd, RN
Health Science
College of Allied Health
National University Philippines

MERISSA B. OCAMPO, Ph.D.
Health, ESL Educator & Researcher
Fukushima Gakuin, Japan

RICHARD M. RILLO
Applied Linguistics
Language Department/Graduate School
Centro Escolar University, Philippines

ZENAIDA M. SUMALDE, Ph.D.
Natural Resource & Environmental Economics
Department of Economics
College of Economics and Management
University of the Philippines, Philippines

RAVEN KAYE S. DELA CRUZ
Publication Staff
CMU Journal of Science

FERDINAND JR. D. BASCONES, MIT
Layout Artist

Philippines Copyright © 2019 by Central Mindanao University, Musuan, Bukidnon, Philippines
All rights reserved. No part of this publication may be reproduced, stored in a retrieval or transmitted in a way or any means, mechanical, photocopying, recording or otherwise, without prior written permission of the copyright holder.

ISSN: 0116-7847 | ISSN Online: 2704-3703
Printed in the Philippines by: Central Mindanao University Press, Central Mindanao University
University Town, Maramag, Bukidnon 8710 Philippines

Aims and Scope

CMU Journal of Science (CMUJS), published by Central Mindanao University, is an international, multidisciplinary scientific journal with peer review and open access. It welcomes original research, short communications and reviews from national, regional and international contributors.

The journal promotes scientific knowledge, technological innovation and sustainable human development. Its current areas of interest include:

- Agricultural economics and agribusiness
- Environmental sociology and human ecology
- Rural sociology and community development
- Health social sciences and medical anthropology
- Science and technology studies

Editorial Policy

Editors initially assess scope, originality, quality, ethical compliance and submission requirements. Unsuitable papers may be returned or declined before external review.

Suitable manuscripts undergo double-blind peer review; author and reviewer identities remain confidential. Normally, at least two independent specialists evaluate each paper. Additional assessment may be requested when recommendations differ substantially.

Authors must address reviewer comments and explain their revisions. Major revisions may undergo further review. The Editor-in-Chief or designated Associate Editors make the final acceptance or rejection decision using scholarly merit, reviewer assessments and ethical compliance.

Preliminary screening includes plagiarism and grammar checks. Manuscripts must meet the stated threshold of at least 85% originality or no more than 15% similarity. Papers that fail are advised to revise and resubmit.

CMUJS follows COPE principles. Authors must report findings honestly, acknowledge sources, disclose conflicts and funding, and obtain applicable ethics approval and informed consent. All named authors must qualify for authorship and approve the work. Misconduct may result in corrections, expressions of concern or retractions.

Published articles are freely accessible online. No publication processing fee is charged. A printed copy costs Php 250.00; the main author may receive a free copy of the issue containing the article.

Guidelines for Manuscript Submission

Submit original, unpublished work that is not under consideration by another journal. Obtain all authors' consent and permission for reused material.

- Register or sign in at js.cmu.edu.ph/CMUJS, download the official template and submit online.
- Remove author names and affiliations from the manuscript.
- Use Letter paper (8.5 × 11 inches), 1-inch margins, 12-point Times New Roman and double spacing.
- Limit the paper to 6,000 words, including tables and figures.
- Use Word 2007 or later; Excel may be used for graphs and tables. Consult publication staff about other software.
- Prefer a title of 12 words or fewer, placed on the first page.
- Provide a separate 100–200-word abstract stating purpose, principal findings and conclusions. Avoid citations and unfamiliar abbreviations.
- Supply 3–5 specific keywords; italicize the keywords heading.
- Include introduction, methodology, results and discussion, conclusion, and references.
- Number tables and figures by appearance. Place figure labels below illustrations and table titles above tables.
- Arrange English-language checking before submission.

The introduction should explain the rationale and objectives. Methods should identify materials, procedures, study duration and location, with citations for adopted methods. Discuss findings against objectives and support conclusions with results.

Tables and figures should follow the latest edition of APA format.

For template, reference instructions and complete policies: js.cmu.edu.ph/CMUJS

For editorial inquiries: journalofscience@cmu.edu.ph

INTRODUCTION TO THE ISSUE

It is with great honor and profound appreciation that we present Volume 30, Issue 1 of this journal, a milestone made possible through the collective dedication of our authors, reviewers, editorial board, and all those who steadfastly support the advancement of scholarly excellence. This issue features a diverse collection of rigorously peer-reviewed studies that address timely and significant concerns across education, public health, food science, engineering, environmental science, nutrition, literature, and communication. Together, these contributions demonstrate the breadth of contemporary research and its capacity to address pressing societal challenges, inform policy and practice, and promote innovation across disciplines.

We extend our sincere gratitude to our authors for entrusting us with their scholarly work, to our reviewers for their invaluable expertise and thoughtful evaluations, and to our readers for their continued engagement and support. Your dedication ensures that this journal remains a meaningful forum for academic discourse and a lasting contribution to the scholarly and professional community.



EINSTINE M. OPISO
The Editor-in-Chief

CMU Journal of Science
The Official Scientific Journal of Central Mindanao University
ISSN Print: 0116-7847 js.cmu.edu.ph ISSN Online: 2704-3703

Research Article

Self-Assessment of Social Communication Skills: Insights into Verbal, Nonverbal, and Listening Aspects

Kaisheng Wang 1, Maria Cecilia C. Ycong 2

1 Graduate School of Education, Trinity University of Asia; kaishengnwang@tua.edu.ph

2 Graduate School of Education, Trinity University of Asia; mccycong@tua.edu.ph

A B S T R A C T.

Social communication skills are essential for success in collaborative learning and workplace settings, yet research examining these skills in Asian contexts remains limited. This study examined how musical engagement (rhythm, melody, and harmony) is associated with students' self-assessed social communication skills (verbal, non-verbal, and listening) among 227 Cangzhou Vocational and Technical College students, where workplace readiness and team-based learning are emphasized. A descriptive-correlational design was used, with data collected via self-assessment questionnaires and analyzed using Microsoft Excel and Jamovi. Results indicated that rhythmic engagement was associated with timing and coordination, melodic engagement was linked to verbal fluency and emotional expression, and harmonic engagement was associated with active listening and adaptability. Differences were observed across gender and performance rating, with female students and higher-performing students reporting stronger engagement. These findings suggest environments. Educators may use rhythmic tasks to build coordination, melodic exercises to support verbal development, and harmonic activities to strengthen group collaboration. Future research may examine the longer-term effects of musical engagement on communication development.

Keywords: Musical engagement, social communication, rhythm, collaborative learning, vocational education

Citation: Wang, K., & Ycong, M. C. (2026). Self-Assessment of Social Communication Skills: Insights into Verbal, Non-Verbal, and Listening Aspects. CMU Journal of Science, 30(1), 05

Academic Editor: Dr. Einstine M. Opiso

Received: April 2, 2025
Revised:February 19, 2026
Accepted: March 5, 2026
Published: July 2, 2026

Copyright: © 2024 by the authors. Submitted for possible open access publication under the terms and conditions of the Creative Commons Attribution (CC BY) license (https://creativecommons.org/licenses/by/4.0/).

INTRODUCTION

Communicating well is crucial for success in academic, professional, and social contexts, particularly for students in vocational education who often work collaboratively in practical learning environments. In vocational settings, communication is not only academic but also task-based—students must coordinate actions, negotiate roles, follow instructions, and respond to peers in real time. These competencies mirror workplace demands, making social communication skills a core component of vocational readiness. Social communication skills, including verbal, non-verbal, and listening, enable students to express themselves, interpret cues, and engage in meaningful interactions [1]. However, developing these skills requires more than conventional teaching methods. It calls for experiential learning that fosters interaction and creativity. Combining structure and expression, music education offers a practical approach to developing communication skills by engaging students cognitively, emotionally, and socially [2, 3].

Conventional communication training in vocational education often relies on lectures, scripted role-plays, or short presentation tasks. While useful, these approaches may not consistently engage students' embodied coordination, emotional expression, and active listening simultaneously. Music-based engagement offers an experiential and interactive alternative in which learners practice timing, turn-taking, attention, and group responsiveness in a structured yet motivating environment. For this reason, music-based activities may complement standard communication training by strengthening communication skills through repeated, collaborative practice.

Music provides an immersive environment where students can practice interaction through various activities involving rhythm, melody, and harmony. Rhythm, the backbone of musical engagement, enhances coordination and teamwork by synchronizing group activities [4]. Melodic engagement stimulates creativity and emotional expression, helping students articulate their thoughts and emotions [5]. Harmony promotes active listening and collaboration, as students must balance individual contributions with group efforts to achieve collective success [6]. Together, these dimensions of music contribute to holistic student development, strengthening their communication skills and ability to collaborate effectively in real-world settings.

Despite the recognized benefits of musical engagement, empirical research examining its specific influence on social communication skills in vocational education remains limited, particularly in Asian contexts. Addressing this gap, the present study examined how rhythm, melody, and harmony are associated with students' verbal, non-verbal, and listening communication skills at Cangzhou Vocational and Technical College, with the goal of informing practical, classroom-based strategies for vocational learning.

METHODOLOGY

2.1 Research Design

This study employed a descriptive-correlational research design to examine the relationship between students' musical engagement (rhythm, melody, and harmony) and their self-assessed social communication skills (verbal, non-verbal, and listening) in a vocational education context. This design enabled the analysis of associations between participants' questionnaire responses on musical engagement and communication outcomes. Data were collected through self-assessment questionnaires and analyzed using Microsoft Excel and Jamovi to identify patterns and statistically significant relationships that may inform practical interventions in vocational education.

2.2 Participants

The participants consisted of 227 students enrolled at Cangzhou Vocational and Technical College (Academic Year 2024–2025), with an age range of 18–21 years. A stratified random sampling method was employed to ensure proportional representation across year level and gender. Academic performance rating was also recorded to allow subgroup comparisons. These participant characteristics (gender, year level, and performance rating) were used to describe the sample and to examine differences in musical engagement and social communication skills across groups.

2.3 Instrumentation

Data collection utilized a structured self-assessment questionnaire to measure musical engagement and social communication skills. The questionnaire comprised two main sections: (1) students' engagement in rhythm-, melody-, and harmony-based activities, and (2) students' self-assessed verbal, non-verbal, and listening communication skills. Items were

adapted from existing instruments used in prior music education research to support content relevance and construct coverage. Reliability was established through a pilot test, yielding an overall Cronbach's alpha of 0.905, indicating high internal consistency. The instrument generated quantitative scores that enabled statistical analysis of the relationship between musical engagement and social communication skills.

2.4 Data Gathering Procedure

Data were collected through on-site administration of the self-assessment questionnaire, ensuring that students completed it under standardized conditions to maintain consistency. The survey was administered in classrooms on campus during Academic Year 2024–2025 and required approximately 10–15 minutes to complete. Before participation, students were briefed on the purpose of the study and the voluntary nature of participation, and informed consent was obtained. The pre-survey briefing was procedural (i.e., instructions and consent) and did not include coaching on how to answer the items. Participants were informed that they could withdraw at any time without penalty. No identifying information was collected; responses were treated confidentially and used strictly for research purposes. The collected data were reviewed for completeness before the analysis phase.

2.5 Data Analysis

Data analysis was conducted using descriptive and inferential statistics, with Microsoft Excel and Jamovi employed for computation and interpretation. Descriptive statistics (frequency, percentage, mean, and standard deviation) were used to summarize respondents' profiles and the levels of musical engagement and social communication skills. Because the measures were based on Likert-type responses, non-parametric tests were applied for group comparisons: Mann–Whitney U was used to test differences by gender, while Kruskal–Wallis was used to test differences across year level and performance rating. Spearman's rho correlation was used to determine the relationships between musical engagement (rhythm, melody, harmony) and social communication skills (verbal, non-verbal, listening). Statistical significance was set at $p < 0.05$.

RESULTS AND DISCUSSION

This section presents the descriptive and inferential results on students' musical engagement (rhythm, melody, and harmony) and self-assessed social communication skills (verbal, non-verbal, and listening). Descriptive statistics summarize the levels of engagement and communication skills. For inferential analysis, non-parametric tests (Mann–Whitney U and Kruskal–Wallis) were used to examine group differences across gender, year level, and performance rating. Spearman's rho correlation was used to determine the associations between musical engagement dimensions and social communication skills. The results are presented according to the study objectives and corresponding tables.

3.1. Levels of Musical Engagement of Students

This subsection reports students' self-assessed levels of musical engagement across the three dimensions of rhythm, melody, and harmony. The tables below summarize the mean ratings and verbal interpretations for each dimension, providing an overall profile of students' engagement with music-related activities in the vocational college context.

3.1.1 Rhythm

This subsection presents students' self-assessed engagement with the rhythmic dimension of musical activities. Table 1 reports the mean scores and verbal interpretations for the rhythm indicators and shows how consistently students rated their rhythmic engagement across the listed statements.

Table 1. Self-Assessment of Students' Musical Engagement in Terms of Rhythm.

	Indicator	Mean	Verbal Interpretation
1	Engaging with the rhythm of music enhances overall music appreciation?	4.32	Highly Engaged
2	The ability to actively participate in the rhythm of music contributes to a deeper engagement with the piece.	4.52	Highly Engaged
3	Rhythm plays a crucial role in determining the level of engagement and enjoyment of individuals experience when listening to music.	4.59	Highly Engaged
4	Engaging with the rhythm of music can increase one's emotional connection to the piece.	4.63	Highly Engaged
5	Rhythm is an essential element in music that significantly impacts how engaged listeners feel with a musical composition.	4.61	Highly Engaged
	OVERALL MEAN	4.59	Highly Engaged

Note: 4.21-5.00 (Highly Engaged) | 3.41-4.20 (Engaged) | 2.61-3.40 (Moderately Engaged) | 1.81-2.60 (Less Engaged) | 1.00-1.80 (Not Engaged)

Table 1 shows that students reported consistently high engagement with rhythm-related musical activities, with an overall mean of 4.59 ("Highly Engaged"). All indicators fell within the "Highly Engaged" range (M = 4.32–4.63). The highest-rated item was "Engaging with the rhythm of music can increase one's emotional connection to the piece" (M = 4.63), followed by "Rhythm is an essential element in music that… [how engaged listeners feel]" (M = 4.61). The lowest mean, while still within the "Highly Engaged" range, was recorded for "Engaging with the rhythm of music enhances overall music appreciation" (M = 4.32). Overall, the results indicate a consistently high level of self-reported rhythmic engagement among the respondents.

3.1.2 Melody

This subsection presents students' self-assessed musical engagement in terms of melody. Table 2 summarizes the mean ratings and verbal interpretations for the melody indicators.

Table 2. Self-Assessment of Students' Musical Engagement in Terms of Melody

	Indicator	Mean	Verbal Interpretation
1	Melody plays a significant role in with the overall music experience.	4.57	Highly Engaged
2	The catchy nature of a melody can greatly increase engagement with a musical piece.	4.62	Highly Engaged
3	Melody is a crucial element in determining how engaged and attentive an individual when experiencing music.	4.70	Highly Engaged

4	The complexity or simplicity of a melody can significantly impact the level of engagement with a musical composition.	4.60	Highly Engaged
5	A memorable melody is essential for maintaining listener engagement throughout a musical piece.	4.53	Highly Engaged
	OVERALL MEAN	4.61	Highly Engaged

Note: 4.21-5.00 (Highly Engaged) | 3.41-4.20 (Engaged) | 2.61-3.40 (Moderately Engaged) | 1.81-2.60 (Less Engaged) | 1.00-1.80 (Not Engaged))

Table 2 indicates that students reported a consistently high level of melody-related engagement, with an overall mean of 4.61 ("Highly Engaged"). All indicators were rated within the "Highly Engaged" range (M = 4.53–4.70). The highest-rated item was "Melody is a crucial element in determining how engaged and attentive an individual is when experiencing music" (M = 4.70), followed by "The catchy nature of a melody can greatly increase listener engagement with a musical piece" (M = 4.62). The lowest mean, while still within the "Highly Engaged" range, was recorded for "A memorable melody is essential for maintaining listener engagement throughout a musical piece" (M = 4.53). Overall, the results suggest strong self-reported engagement with melodic aspects of musical activities among the respondents. The following subsection presents students' engagement in terms of harmony.

3.1.3 Harmony

This subsection presents students' self-assessed musical engagement in terms of harmony. Table 3 summarizes the mean ratings and verbal interpretations for the harmony indicators.

Table 3. Self-Assessment of Students' Musical Engagement in Terms of Harmony

	Indicator	Mean	Verbal Interpretation
1	The effective use of harmony in musical compositions enhance overall engagement and emotional response.	4.54	Highly Engaged
2	The incorporation of complex harmonies improve the level of interaction and engagement between musicians and their audience during performances.	4.59	Highly Engaged
3	The use of harmony as a structural element in music contributes to the long-term engagement and appreciation of listeners.	4.56	Highly Engaged
4	The balance and interplay of different harmonies within a musical piece affect the listener's engagement and emotional connection to music.	4.53	Highly Engaged
5	Teaching the principles and application of harmony increases students' engagement and understanding of musical compositions.	4.58	Highly Engaged
	OVERALL MEAN	4.56	Highly Engaged

Note: 4.21-5.00 (Highly Engaged) | 3.41-4.20 (Engaged) | 2.61-3.40 (Moderately Engaged) | 1.81-2.60 (Less Engaged) | 1.00-1.80 (Not Engaged)

Table 3 indicates that students reported a consistently high level of harmony-related engagement, with an overall mean of 4.56 ("Highly Engaged"). All indicators were rated within the "Highly Engaged" range (M = 4.53–4.59). The highest-rated item was "The incorporation of complex harmonies improves the level of interaction and engagement between musicians and their audience during performances" (M = 4.59), followed by "Teaching the principles and application of harmony increases students' engagement and understanding of musical compositions" (M = 4.58). The lowest mean, while still within the same category, was recorded for "The balance and interplay of different harmonies…" (M = 4.53). Overall, the results reflect strong self-reported engagement with harmonic aspects of musical activities among the respondents.

With these results on musical engagement, the next section presents students' self-assessed social communication skills.

In summary, students reported "Highly Engaged" levels across rhythm (overall mean = 4.59), melody (overall mean = 4.61), and harmony (overall mean = 4.56), indicating consistently high self-assessed engagement across all three musical dimensions.

3.2 Assessment of Social Communication Skills

This subsection presents students' self-assessed social communication skills across the verbal, non-verbal, and listening dimensions. The tables below report the mean scores and verbal interpretations for each dimension, providing an overall profile of students' perceived communication skills in the context of their music-related learning experiences.

3.2.1 Verbal Communication

Table 4 presents students' self-assessed verbal communication skills in relation to their music course experiences. Overall, students reported a high level of verbal communication, with all indicators interpreted as "Highly Engaged."

Table 4. Self-Assessment of the Students of the Verbal Aspect of Social Communication Skills.

	Indicator	Mean	Verbal Interpretation
1	Achieving success in taking the Music course requires constant communication with college classmates.	4.46	Highly Engaged
2	Discussing musical concepts with instructors enhances my understanding of the course material.	4.46	Highly Engaged
3	Sharing feedback about musical performance is crucial for improvement in music courses.	4.44	Highly Engaged
4	Asking questions during music classes helps clarify my doubts and enhances learning.	4.53	Highly Engaged
5	Providing constructive criticism to peers is essential for growth in music performance skills.	4.46	Highly Engaged

OVERALL MEAN	4.47	Highly Engaged

Note: 4.21-5.00 (Highly Engaged) | 3.41-4.20 (Engaged) | 2.61-3.40 (Moderately Engaged) | 1.81-2.60 (Less Engaged) | 1.00-1.80 (Not Engaged)

Table 4 shows that students' verbal communication skills were rated as "Highly Engaged", with an overall mean of 4.47. All indicators fell within the "Highly Engaged" range (M = 4.44–4.53). The highest-rated item was "Asking questions during music classes helps clarify my doubts and enhances learning" (M = 4.53), while the lowest mean was recorded for "Sharing feedback about musical performance is crucial for improvement in music courses" (M = 4.44). Overall, the results indicate consistently high self-reported verbal communication among the respondents within the context of music-related learning activities.

3.2.2 Non-Verbal Communication

Table 5 presents students' self-assessed non-verbal communication skills in the context of music-related learning experiences. The table summarizes the mean ratings and verbal interpretations for indicators related to gestures, facial expressions, body language, synchronization, and eye contact.

Table 5. Self-Assessment of the Students of the Non-Verbal Aspect of Social Communication Skills**.**

	Indicator	Mean	Verbal Interpretation
1	Gestures are very important in communicating with my classmates through music.	4.45	Highly Engaged
2	Facial expressions contribute to enhance interpersonal relationships among students, especially in understanding music.	4.52	Highly Engaged
3	Body language during performances can significantly affect the overall presentation of a piece.	4.50	Highly Engaged
4	The synchronization of movements among group members is essential for a cohesive performance.	4.52	Highly Engaged
5	Eye contact among ensemble members helps in maintaining tempo and dynamics during performance.	4.43	Highly Engaged
	OVERALL MEAN	4.49	Highly Engaged

Note: 4.21-5.00 (Highly Engaged) | 3.41-4.20 (Engaged) | 2.61-3.40 (Moderately Engaged) | 1.81-2.60 (Less Engaged) | 1.00-1.80 (Not Engaged)

Table 5 shows that students' non-verbal communication skills were rated as "Highly Engaged", with an overall mean of 4.49. All indicators fell within the "Highly Engaged" range (M = 4.43–4.52). The highest-rated items were "Facial expressions contribute to enhancing interpersonal relationships…" (M = 4.52) and "The synchronization of movements among group members is essential for a cohesive performance" (M = 4.52). The lowest mean, while still within the same category, was recorded for "Eye contact among ensemble

members helps in maintaining tempo and dynamics during performance" (M = 4.43). Overall, the results indicate consistently high self-reported non-verbal communication among the respondents.

3.2.3 Listening

Table 6 presents students' self-assessed listening skills in the context of music-related learning experiences. The table summarizes mean ratings and verbal interpretations for indicators related to attentive listening during practice, group discussion, instructor guidance, and listening-based tasks.

Table 6. Self-Assessment of the Students of the Listening Aspect of Social Communication Skills

	Indicator	Mean	Verbal Interpretation
1	It is important for me to listen to the ideas of my classmates during our practice and performance.	4.46	Highly Engaged
2	Listening to recordings of musical performances as a group aids in understanding different interpretations of music.	4.43	Highly Engaged
3	Receiving listening assignments from instructors improves my ability to critique music effectively.	4.50	Highly Engaged
4	Understanding the nuances of music requires attentive listening to instructors' explanations.	4.50	Highly Engaged
5	Active listening during group discussions helps in better collaboration for ensemble performances.	4.50	Highly Engaged
	OVERALL MEAN	4.48	Highly Engaged

Note: 4.21-5.00 (Highly Engaged) | 3.41-4.20 (Engaged) | 2.61-3.40 (Moderately Engaged) | 1.81-2.60 (Less Engaged) | 1.00-1.80 (Not Engaged)

Table 6 shows that students' listening skills were rated as "Highly Engaged," with an overall mean of 4.48. All indicators fell within the "Highly Engaged" range (M = 4.43–4.50). The highest-rated items were "Receiving listening assignments from instructors improves my ability to critique music effectively" (M = 4.50), "Understanding the nuances of music requires attentive listening to instructors' explanations" (M = 4.50), and "Active listening during group discussions helps in better collaboration for ensemble performances" (M = 4.50). The lowest mean, while still within the same category, was recorded for "Listening to recordings of musical performances as a group aid in understanding different interpretations of music" (M = 4.43). Overall, the results indicate consistently high self-reported listening skills among the respondents.

Overall, students reported "Highly Engaged" levels across all three social communication dimensions: verbal (overall mean = 4.47), non-verbal (overall mean = 4.49), and listening (overall mean = 4.48). These findings indicate consistently high self-assessed social communication skills among the respondents within the context of music-related learning activities

D I S C U S S I O N

The findings of this study indicate that students' musical engagement (rhythm, melody, and harmony) is associated with their self-assessed social communication skills (verbal, non-verbal, and listening), particularly within vocational settings where teamwork, task coordination, and collaborative performance are central. Consistent with experiential learning perspectives, music-related activities provide structured opportunities for interaction, reflection, and shared participation, which may reinforce communicative behaviors that are relevant to vocational readiness. [2,19]

4.1 Rhythm, non-verbal coordination, and group synchronization

Rhythmic engagement was rated highly by students and appears conceptually aligned with non-verbal communication demands in group-based learning. Rhythm is frequently linked to timing, coordination, and synchronized participation, which are also foundational to effective non-verbal interaction in collaborative settings. [8,27] The consistently high self-assessments in rhythmic engagement may be partly explained by evidence that rhythmic patterns influence emotional response and engagement through neural entrainment and affective processing. [10] This aligns with the view that rhythm can shape participants' perception of flow and sustained involvement in learning tasks, thereby supporting consistent participation during group activities. [11] In applied vocational contexts, rhythmic coordination may resemble real task-based collaboration where students must align pacing, roles, and actions. Studies on movement-based rhythm play further support the role of rhythmic interaction in social expressiveness and coordinated physical communication. [24]

4.2 Melody, sustained attention, and verbal expression

Melodic engagement also received consistently high ratings and appears closely linked with the verbal dimension of communication. Melody is often discussed as supporting expressive performance and emotional articulation, which may lower participation barriers and encourage verbal contributions in learning settings. [21] In addition, experimental evidence suggests that music engagement can support attention-related outcomes, which may facilitate students' focus during discussions, peer feedback, and instructor-led clarification. [15] Related scholarship on emotion regulation emphasizes how musical elements, including melodic structure, can strengthen emotional engagement and sustained attention—processes that can support communicative participation. [16] Furthermore, the use of musical text as a learning medium has been associated with language expression and meaning-making, which is relevant to verbal interaction and classroom communication. [28] Together, these studies provide converging support for why students who report high melodic engagement may also report strong verbal communication skills.

4.3 Harmony, active listening, and adaptive responsiveness

Harmony-related engagement reflects the need to balance individual contributions within a shared structure, which is strongly aligned with listening and adaptive responsiveness. Ensemble-based contexts require learners to attend to others' input, adjust timing and dynamics, and maintain coherence—behaviors that mirror workplace collaboration and conflict management. [17,29] Prior work also emphasizes that music engagement can support socio-emotional functioning and interpersonal outcomes, which may reinforce cooperative responsiveness during group tasks. [18] Moreover, structured feedback processes (audio and written feedback, guided critique, and instructor assignments) have been linked with improved reflective listening and evaluative processing, which can support

adaptive communication in collaborative learning environments. [25] In this sense, harmony can be interpreted as a meaningful model for vocational teamwork because it demands attentive listening, real-time adjustment, and shared accountability for group outcomes. [29]

4.4 Vocational relevance and implications for applied learning contexts

A key contribution of this study is its vocational relevance. While communication skills are widely studied, vocational learning environments often require applied and performance-based communication—students must negotiate roles, interpret non-verbal cues during collaboration, and respond to peers and instructors under task constraints. [19] The consistently high engagement and communication ratings in this study suggest that music-related activities may provide a structured setting for practicing these competencies. This aligns with broader work highlighting that music-based education can support competence development and holistic growth through structured participation and skills transfer. [3,7] In addition, a systematic review on music training and prosocial outcomes supports the broader idea that music engagement may be linked with interpersonal orientation, which is relevant to team-based vocational performance. [13]

4.5 Demographic patterns and differentiated support

Differences across gender and performance rating indicate that students may experience music engagement and communication behaviors differently. Prior research suggests that engagement patterns can differ by gender and support structures, which may influence students' participation and responsiveness in collaborative tasks. [20] Rather than viewing these differences as fixed, the findings suggest the value of differentiated supports—such as structured peer roles, guided participation routines, and tiered communicative tasks—to ensure equitable opportunities for verbal expression, non-verbal coordination, and active listening in group learning contexts. [19]

These discussion points contextualize the study's findings within existing literature and highlight how musical engagement aligns with communication practices in vocational learning environments. The following section presents the study's conclusions and practical recommendations.

CONCLUSION & RECOMMENDATIONS

This study indicates that students' musical engagement in rhythm, melody, and harmony was positively associated with their self-assessed social communication skills (verbal, non-verbal, and listening) in a vocational education context. Overall findings suggest that rhythm-related engagement aligns with non-verbal coordination in group activities, melody-related engagement aligns with verbal expression and participation, and harmony-related engagement aligns with attentive listening and adaptive collaboration during ensemble or team-based tasks. These patterns support the relevance of music-based learning contexts as a practical setting where communication behaviors can be practiced within structured group interaction.

Differences were observed across gender and performance rating in some communication-related outcomes, suggesting that students may engage with music-based learning and communication tasks in varied ways. This highlights the need for flexible and inclusive instructional approaches that provide equitable opportunities for verbal participation, non-verbal coordination, and active listening across learner groups.

Recommendations. To strengthen communication skills through music-informed strategies in vocational education, the following actions are recommended:

1. Embed brief rhythm-based coordination tasks (e.g., timed group clapping/drumming patterns or synchronized movement drills) in teamwork-oriented modules to support pacing, role coordination, and non-verbal alignment.
2. Integrate melody-based verbal practice activities (e.g., short guided singing lines, structured musical storytelling, or scripted call-and-response) in communication-focused lessons to encourage articulation, confidence, and participation.
3. Use harmony-based ensemble tasks for listening development, such as small-group performance roles requiring students to monitor peers' cues and adjust their timing, dynamics, or contributions to maintain group cohesion.
4. Implement periodic monitoring (e.g., short rubrics or checklists for verbal participation, non-verbal coordination, and listening behaviors) to guide instructional adjustments and targeted support.

5. Provide faculty development on implementing music-integrated collaborative activities aligned with course outcomes and vocational competencies.

Limitations and future research. Because the study used self-report data from a single setting and a descriptive-correlational design, the findings do not establish causal effects. Future studies may use longitudinal or quasi-experimental designs and include additional vocational contexts to examine whether music-integrated strategies lead to measurable improvements in communication skills and workplace readiness over time.

IMPLICATIONS

The findings of this study offer practical implications for educators, curriculum developers, and policymakers in vocational education. Students who reported higher musical engagement (rhythm, melody, and harmony) also reported higher levels of social communication skills (verbal, non-verbal, and listening), suggesting that music-related learning contexts may be a useful platform for practicing communication behaviors relevant to team-based learning and workplace interaction. Given the study's descriptive-correlational and self-report nature, these implications should be interpreted as practice-oriented applications rather than evidence of causal effects.

From an instructional perspective, rhythm-related engagement may inform the use of short coordination tasks (e.g., synchronized movement, timing drills, or group rhythm patterns) within collaborative modules where learners must align roles, pacing, and group actions. For curriculum design, melody-related engagement may support the inclusion of structured expressive tasks (e.g., guided musical storytelling or call-and-response activities) that encourage participation, articulation, and confidence in communication-focused lessons. In parallel, harmony-related engagement highlights the relevance of ensemble-based tasks that require attentive monitoring of peers and adaptive response, which conceptually aligns with listening demands in workplace collaboration (e.g., responding to team cues, maintaining group coherence, and negotiating shared outcomes).

At the institutional level, the observed differences across gender and performance rating suggest that implementation may benefit from differentiated participation structures to ensure equitable opportunities for verbal contribution, non-verbal coordination, and active listening. Periodic monitoring of communication behaviors (e.g., short rubrics or checklists aligned with course outcomes) may help instructors adjust task difficulty and group roles to better support diverse learners. Overall, embedding music-integrated collaborative activities across vocational subjects may contribute to developing transferable communication competencies that align with workplace readiness and collaborative performance.

Author Contributions: Conceptualization, Y.Y.; Methodology, Y.Y. and P.A.A.; Writing—Original Draft, Y.Y.; Writing—Review & Editing, P.A.A. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Data Availability Statement: Data is available upon reasonable request from the corresponding authors.

Acknowledgments: Thanks to the student participants and academic mentors who supported this research.

Conflicts of Interest: The authors declare no conflict of interest.

REFERENCES

1. Dano, G. C. (2024). Strengthening outcome-based education: Capability approach perspective. *CMU Journal of Science, 28*(1), 5–15.
2. Aycan, K. (2021). Is Experiential Learning Possible with Active Music Education? In IntechOpen eBooks. IntechOpen.
3. He, Y., & Suttachitt, N. (2024). The Development of Music Teaching Strategies for Promoting Music Learning Competency for Elementary School Students Under the Core Literacy of Music Academic Subjects. Journal of Ecohumanism, 3(8).
4. Rushton, R., Kossyvaki, L., & Terlektsi, E. (2022). Music-based interventions for people with profound and multiple learning disabilities: A systematic review of the literature [Review of Music-based interventions for people with profound and multiple learning disabilities: A systematic review of the literature]. Journal of Intellectual Disabilities, 27(2), 370. SAGE Publishing. https://doi.org/10.1177/17446295221087563.
5. Rockell, K. (2024). "An Intercultural Lens on the Japanese Noh Theater Play Takasago." CMU Journal of Science. 28(2), 52.
6. Li, D. (2022). Music Therapy in Mental Health and Emotional Diversion of Primary and Secondary

School Students. Occupational Therapy International, 2022, 1.
7. Corton-Heras, M.-O., Hayes, A. G., Soliveres-Buigues, R., & Parejo, J. L. (2023). The Mediation of Music in the Development of Intrapersonal and Action Skills in Early Teacher Education. Qualitative Research in Education, 12(2), 116. https://doi.org/10.17583/qre.10748
8. Stolp, E., Moate, J., Saarikallio, S., Pakarinen, E., & Lerkkanen, M. (2022). Exploring agency and entrainment in joint music-making through the reported experiences of students and teachers. Frontiers in Psychology, 13. https://doi.org/10.3389/fpsyg.2022.964286
9. Lauzon, A. P., Russo, F., & Harris, L. R. (2020). The influence of rhythm on detection of auditory and vibrotactile asynchrony. Experimental Brain Research, 238(4), 825. https://doi.org/10.1007/s00221-019-05720-x
10. Ding, J., Zhang, X., Liu, J., Hu, Z., Yang, Z., Tang, Y., & Ding, Y. (2025). Entrainment of rhythmic tonal sequences on neural oscillations and the impact on subjective emotion. Scientific Reports, 15(1). https://doi.org/10.1038/s41598-025-98548-1
11. Jian, Z. (2022). Sustainable Engagement and Academic Achievement Under Impact of Academic Self-Efficacy Through Mediation of Learning Agility—Evidence From Music Education Students. Frontiers in Psychology, 13. https://doi.org/10.3389/fpsyg.2022.899706
12. Huang, J., & Li, X. (2022). Effects and Applications of Music Therapy on Psychological Health: A Review [Review of Effects and Applications of Music Therapy on Psychological Health: A Review]. Advances in Social Science, Education and Humanities Research/Advances in Social Science, Education and Humanities Research. https://doi.org/10.2991/assehr.k.220110.186
13. Biasutti, M., & Concina, E. (2022). Music training, empathy, and prosocial behavior: A systematic review. Frontiers in Psychology, 13, 841715.
14. Gkintoni, E., Farmakopoulou, I., & Theodoratou, M. (2023). Neuromusic Education in Cognition and Quality-of-Life Promotion. An Outline. Technium Social Sciences Journal, 40, 223. https://doi.org/10.47577/tssj.v40i1.8347
15. Kasuya-Ueba, Y., Zhao, S., & Toichi, M. (2020). The Effect of Music Intervention on Attention in Children: Experimental Evidence. Frontiers in Neuroscience, 14. https://doi.org/10.3389/fnins.2020.00757
16. Chong, H. J., Kim, H. J., & Kim, B. (2024). Scoping Review on the Use of Music for Emotion Regulation. Behavioral Sciences, 14(9), 793. https://doi.org/10.3390/bs14090793
17. Hopkins, M. (2019). Collaborative Composing in Middle and High School Chamber Music Ensembles. American String Teacher, 69(1), 47. https://doi.org/10.1177/0003131318816084
18. Gustavson, D. E., Coleman, P. L., Iversen, J. R., Maes, H. H., Gordon, R. L., & Lense, M. D. (2021). Mental health and music engagement: review, framework, and guidelines for future studies [Review of Mental health and music engagement: review, framework, and guidelines for future studies]. Translational Psychiatry, 11(1). Springer Nature. https://doi.org/10.1038/s41398-021-01483-8
19. Varma, S. B., Rahmat, N. H., Sim, M. S., Abidin, N. S. Z., Jamil, N. S. Z. M., & Mei, H. C. (2022). An Investigation of Classroom Communication Strategies Across Discipline. International Journal of Academic Research in Business and Social Sciences, 12(5). https://doi.org/10.6007/ijarbss/v12-i5/13190
20. Bru, E., Virtanen, T., Kjetilstad, V., & Niemiec, C. P. (2019). Gender Differences in the Strength of Association between Perceived Support from Teachers and Student Engagement. Scandinavian Journal of Educational Research, 65(1), 153. https://doi.org/10.1080/00313831.2019.1659404
21. Meissner, H. (2021). Theoretical Framework for Facilitating Young Musicians' Learning of Expressive Performance. Frontiers in Psychology, 11. https://doi.org/10.3389/fpsyg.2020.584171
22. Rebecchini, L. (2021). Music, mental health, and immunity. Brain Behavior & Immunity - Health, 18, 100374. https://doi.org/10.1016/j.bbih.2021.100374
23. Maisarah, M., Putri, T. H., Fauziyah, N., Saifuddin, M., Nurcahyani, D., Najih, A., & Bakri, B. (2023). Teachers' Non-Verbal Communication in Teaching English to Young Learners. Formosa Journal of Science and Technology, 2(8), 1939. https://doi.org/10.55927/fjst.v2i8.5325
24. Yoshimi, E. (2021). Sociability through the Movement of Young Children: The Effects of Exercise Programs involving Rhythm Play on the Potential for Physical Expression. International Journal of Social Science Studies, 9(4), 43. https://doi.org/10.11114/ijsss.v9i4.5278
25. Sarcona, A., Dirhan, D., & Davidson, P. (2020). An overview of audio and written feedback from students' and instructors' perspective. Educational Media International, 57(1), 47. https://doi.org/10.1080/09523987.2020.1744853
26. Hallam, S. (2021). The power of music: Its impact on the intellectual, social, and personal development of children and young people. International Journal of Music Education, 39(3), 289–302.
27. Hijazi, M. M. K. (2020). Rhythm, Movement Combining and Performance Level of Some Compound Skills in Fencing. Advances in

Physical Education, 10(1), 31. https://doi.org/10.4236/ape.2020.101004

28. McIntire, A. M. (2020). Musical text: An effective instrument in teaching language and culture. Journal of Visual Literacy, 39, 185. https://doi.org/10.1080/1051144x.2020.1826221

29. Pandey, C. D. S. P. (2021). Techniques and Strategies to Develop Active Listening Skills: The Armour for Effective Communication across Business Organizations. Languages and Literatures.

Disclaimer/Publisher's Note: The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of CMUJS and/or the editor(s). CMUJS and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.

CMU Journal of Science
The Official Scientific Journal of Central Mindanao University
ISSN Print: 0116-7847 js.cmu.edu.ph ISSN Online: 2704-3703

Research Article

Exploring the Factors that Influence Students' Decision in Choosing their Accommodation: A Case in the University of Science and Technology of Southern Philippines - CDO

Archemedes G. Wabe 1*, Gerrich Aldin C. Babanto 2

1* Department of Architecture, College of Engineering and Architecture, University of Science and Technology of Southern Philippines; archemedes.wabe@ustp.edu.ph

2 Department of Economics, College of Economics, Business, and Accountancy, Mindanao State University-Iligan Institute of Technology; gerrich.babanto@g.msuiit.edu.ph

Citation: Wabe, A., & Babanto, G. A. (2026). Exploring the Factors that Influence Students' Decision in Choosing their Accommodation: A Case in the University of Science and Technology of Southern Philippines - CDO. CMU Journal of Science, 30(1), 18

Academic Editor: Dr. Ma. Bernadeth Lim

Received: June 18, 2025
Revised: February 25, 2026
Accepted: March 12, 2026
Published: July 2, 2026

Copyright: © 2024 by the authors. Submitted for possible open access publication under the terms and conditions of the Creative Commons Attribution (CC BY) license (https://creativecommons.org/licenses/by/4.0/).

ABSTRACT

This study investigated the socioeconomic profiles, accommodation satisfaction, available safety and security features, attribute importance,and determinants of housing choice among students at the University ofScience and Technology of Southern Philippines – Cagayan de Oro (USTP-CDO). Data were collected through online survey questionnaires administered to 461 students residing in boarding houses or dormitories. Descriptive statistics and binary logistic regression were employed to analyze influencing factors of accommodation choice. Results revealed that 55% of participants reported monthly household incomes ≤₱15,000–within the margins of the ₱13,873 poverty threshold established by the Philippine Statistics Authority in 2023. The study documented substantial safety deficiencies in off-campus accommodations: 62- 72% lacked critical fire safety infrastructure (smoke detectors, evacuation plans, fire suppression systems). Additionally, 71% of evaluated criteria received neutral satisfaction ratings, particularly indoor climate and learning conduciveness. Students endorsed utilities, safety, and hygiene as most important attributes. Binary logistic regression identified transportation costs, current accommodation satisfaction, and safety feature availability as significant predictors of accommodation choice. These findings underscore urgent needs for minimum standards and regulatory oversight to ensure safety, livability and learning conduciveness of student accommodations. The study provides empirical support for university investment in on-campus housing to reduce commuting burdens, ensure safety standards, and support low-income students.

Keywords: Student Accommodation; Safety Features; Satisfaction; Accommodation Preferences; Binary Logistic Regression

INTRODUCTION

Student accommodation is a crucial aspect of a student's experience while pursuing studies away from home. It is a venue for relaxation, repose, recreation, socialization, study, and task completion. Student accommodations may offer a variety of bedroom configurations to meet various preferences, including private rooms with en suite bathrooms, and shared rooms with communal bathroom facilities [1]. Furthermore, facilities and amenities such as living rooms, common kitchen, dining hall, study lounges, fitness gym, jogging paths, and outdoor seating places are offered to promote study-live-play lifestyle balance for students. These facilities facilitate student interaction and socialization, hence cultivating a sense of belonging [2].

There are benefits to living in on-campus student housing, particularly for students' academic success. De Araujo [3] found that after transitioning to on-campus housing, students' GPAs increased instantaneously. This can be linked to students' increased access to academic materials, positive peer influence, and social activities [3]. Balabanian [4] identified that traveling long distances to and from school has a negative impact on students' academic achievement. Furthermore, physical and mental exhaustion because of getting less sleep and preparing early in the morning, as well as having less time to study owing to spending more time traveling, were the key issues affecting pupils [4]. Convenient access to academic resources and facilities, as well as reduced time spent traveling to and from school, may explain why students from far-flung areas seek on-campus housing or rent nearby third-party accommodations. This underlines the accommodation's proximity to the school as one of the most important criteria for students [5].

The quality of student accommodations can significantly differ based on various factors, including the design and layout of the facility, construction quality, safety features, furnishings, available amenities, and both indoor and outdoor environments. The satisfaction of students can be significantly affected by these factors, which evidently impact their academic performance, social life, self-esteem, and both physical and mental health [6, 7, 8, 9, 10, 11]. The design, physical layout, and environmental parameters of communal spaces significantly impact the social behavior of resident students [2]. The unfavorable interior environmental conditions of student housing, including dampness, malfunctioning air-conditioning, mold, and pests, adversely impact students' health [7, 12].

Ensuring that student accommodation is both safe and conducive, while remaining affordable, is essential for supporting students from economically disadvantaged backgrounds. The literature indicates that affordability is a key factor that students consider when selecting an accommodation [13, 14, 15, 16]. Nevertheless, Filipino students residing in budget-friendly accommodations often face hazardous living conditions because of the haphazard conversion of residential buildings into student housing. These types of student housing often fail to obtain the required permits, neglected to implement essential security and fire safety measures, and violated building codes [5].

The implementation of the Universal Access to Quality Tertiary Education Act in the Philippines has democratized access to higher education for disadvantaged sectors, however, the institutionalization of a comprehensive gamut of student support services remains critically insufficient [17, 18]. While prominent State Universities and Colleges (SUCs) in the Philippines, such as the University of the Philippines system, have established on-campus accommodations, many other SUCs, including the University of Science and Technology of Southern Philippines (USTP), have yet to provide such facilities for their growing student population [19, 20]. Consequently, many students reside in nearby repurposed residential areas, such as Sitio Lawsbra, which were characterized by informal construction and a disregard for building codes [21]. The vulnerability of this situation was demonstrated by a December 2022 fire incident in the neighborhood, which displaced several students [22] and highlighted the university's inability to provide on-campus shelter. Despite these documented challenges, no prior studies have systematically evaluated student accommodation safety, satisfaction, and the factors that influence accommodation choice among USTP students, representing a critical gap in understanding students' living conditions and housing needs. Moreover, the insufficient capital investment in accessible and affordable student housing among

many Philippine SUCs indicates a critical gap in governmental understanding regarding the necessity of these facilities for holistic student support. By identifying the specific factors that influence student accommodation choices, this study addresses this information deficit. Understanding these drivers is essential for ensuring that limited institutional resources are strategically allocated toward implementing policies and housing features that most effectively enhance student welfare and academic success.

To understand these multifaceted challenges, ranging from institutional gaps to the immediate physical risks posed by unregulated housing, this study investigates students' current living conditions, satisfaction levels, and the attributes considered when selecting housing. Additionally, this study explores factors influencing the decision to seek specific accommodations through several hypothetical scenarios. An analysis of the socio-economic and demographic profiles of the students, particularly estimated family income, living arrangements, rental expenses, and fare costs serves as a critical lens for understanding the spatial and financial dimensions of residential vulnerability. Beyond these, assessing current conditions and satisfaction levels are essential for identifying gaps where university and local governments can implement interventions to improve the existing housing stock. Moreover, identifying the important attributes for student accommodations provides a vital reference for architects to ensure a conducive living environment. Ultimately, determining the factors that influence accommodation choice through binary logistic regression provides a robust empirical basis for policies to improve student welfare services and infrastructure planning and development.

METHODOLOGY

Study Design, Population, Setting

To determine the appropriate sample size, the study employed Slovin's formula based on the total enrollment of 15,405 students at the USTP CDO Campus during the first semester of the 2023-2024 academic year. With an acceptable margin of error of 0.05, the minimum required sample was calculated at 390 respondents. Eligibility to participate in the survey was restricted to currently enrolled students, regardless of year level, who resided in dormitories, shared rooms, or rented houses and apartments. This criterion also extended to students living with relatives on a rent-free basis. The data collection took place over a three-month period from October to December 2023.

Study Tools, Variables, Data Collection

The study utilized a non-probability convenience sampling technique, specifically employing a voluntary response method. Survey invitations and links were distributed via physical posters with QR codes placed in high-traffic areas and strategically shared within student organization-affiliated social media groups. By leveraging both digital and physical platforms, the study successfully captured a broad range of respondents. A total of 461 valid responses were retained following a rigorous data cleaning process, which involved filtering out incomplete, contradictory, or straight-lined entries. This final sample size exceeds the computed minimum threshold, ensuring the homogeneity, validity, and statistical reliability of the dataset.

To facilitate this collection, the research utilized an online structured survey questionnaire implemented via Google Forms. The instrument was organized into five distinct sections designed to capture a comprehensive view of the student housing experience: (1) socio-economic and demographic profile; (2) availability of safety and security features; (3) satisfaction with current residence; (4) perceived importance of accommodation attributes; and (5) hypothetical scenarios to measure the willingness to avail university accommodation. The first portion of this instrument focused on the socio-economic and demographic profile of the respondents. This section gathered data regarding age, gender, degree program, year level, and provincial address of origin. It also captured vital socio-economic indicators, including parental occupation and estimated monthly household income. Furthermore, it detailed the students' current living conditions, such as the geographic location of their accommodation (barangay and city/municipality), living arrangements (renting or living for free), monthly rent, fare expenses, and the primary mode of transportation used for commuting.

Beyond demographics, the survey employed specific metrics to quantify student perceptions and existing living conditions. The availability of safety and security features was assessed using a dichotomous scale (Yes/No). Respondent satisfaction and attribute importance were further measured using five-point Likert scales. The satisfaction scale ranged from 1 (Very Dissatisfied: completely inadequate) to 5 (Very Satisfied: exceeds expectations), while the importance scale ranged from 1 (Least Important: least priority or considered during the decision process) to 5 (Extremely Important: top priority or essential for the choice). These scales allow for the transformation of qualitative student attitudes into quantitative data points for statistical modeling.

Concluding the survey instrument was a section dedicated to a hypothetical choice scenario, designed to elicit preferences for future student housing. Respondents were presented with two accommodation types: an on-campus option provided by USTP and an off-campus option from a third-party provider. To ensure a controlled comparison, both types were described with identical occupant capacities, safety features, and facilities. Respondents were asked to indicate their maximum willingness to pay (WTP) for rent and to specify their final choice by answering "Yes" or "No" regarding their willingness to avail of the provided hypothetical accommodations. This final data point serves as the dependent variable for the binary logistic regression analysis.

Conceptual Framework

The necessity for student housing is fundamentally anchored in Maslow's Hierarchy of Needs, which identifies shelter as a primary physiological requirement for survival [23]. Beyond providing basic refuge, student accommodation serves as a critical environment that addresses every level of the hierarchy. It fulfills safety and security needs through physical protection (fire safety) and financial stability; belongingness needs through social integration and peer support; and esteem needs by providing privacy and a conducive study environment. Ultimately, high-quality facilities enables self-actualization, allowing students to reach their full academic and holistic potential. Conversely, a lack of institutional support from State Universities and Colleges (SUCs) may stifle this growth, particularly for disadvantaged students whose residential quality is left to the mercy of unregulated market dynamics.

The market dynamics governing these choices are rooted in Demand Theory. The Law of Demand posits that, ceteris paribus, an increase in the price of accommodation leads to a decrease in the quantity demanded [24]. This relationship is shaped by the interaction of key actors: the consumers (students and their rent-paying parents), the suppliers (private landlords), and institutional/regulatory bodies (SUCs and local government). While Consumer Choice Theory suggests that students evaluate housing options against specific preferences to maximize personal utility, Budget Constraint Theory dictates the "affordable set" of these choices [25]. For the majority of students, household income establishes a strict financial delimitation, often forcing a trade-off between their preferences for safety and their actual financial capacity.

This decision-making process is further explained by the interaction between Price Elasticity and Alonso's Trade-off Theory [26]. Students demonstrate varying sensitivities to rent prices versus transportation costs (combined weighted measure of time, distance, and other travel-related variables). Those with high price elasticity for travel often trade off higher rent to live near the university, while those with high rent elasticity trade off proximity, opting for longer commutes to avail of lower rental rates. However, as noted by McFadden and Richter [27] in Random Utility Theory (RUT), students act as stochastically rational agents. This framework suggests that housing selection is a stochastic decision-making process where outcomes are influenced by both measurable factors such as rental price and safety features and random environmental variables, including personal perceptions, aesthetics, and social "vibes" [27].

Building upon these theories, this study identifies the critical factors influencing a student's decision to avail of university-provided accommodation. As illustrated in the Conceptual Framework (Figure 1), several predictors specifically

rent price, fare expense, monthly parental income, availability of safety and security features, perceived importance of accommodation attributes, and current residential satisfaction are hypothesized to determine the choice outcome. These variables represent the economic, architectural, and satisfaction-based factors that dictate whether a student is willing to avail of either an on-campus institutional dormitory or an off-campus third-party accommodation.

Data Analysis

Descriptive statistics were employed to summarize the collected data. This analytical approach served primarily to define and contextualize the socio-economic, socio-spatial, and mobility profiles of the student participants. Additionally, descriptive statistics were utilized to categorize the availability of safety and security features, expressed as percentages. For Likert scale responses, weighted means (WM) were calculated to determine students' overall satisfaction with their current accommodations and to assess their perceived importance of various student accommodation attributes.

Due to the binary nature of the dependent variable (Yes=1, No=0), binary logistic regression was performed using Stata to identify the possible factors (rent price and satisfaction of current accommodation, fare expense, available safety and security features, and perceived importance of student accommodation attributes) that influence whether a student will avail an accommodation if the university or a third-party provider offers it hypothetically.

$$0 \quad \left[\frac{}{1-}\right] = {}_0 + {}_{11} + {}_{22} + \dots$$

Where the dependent variable is a dichotomous outcome, 0=No and 1 = Yes and denotes the natural log of the odds of the outcome; ${}_1$, ${}_2$, ... are predictor variables either dichotomous or continuous; ${}_1, {}_2 \dots$ are the parameters of the predictor variables ; and ${}_0$ is the constant.

For binary logistic regression, the odds of success are:

$$\frac{}{1-} = x\,()$$

The odds ratio can be any nonnegative number. An odds ratio of 1 serves as the baseline for comparison and indicates there is no association between the response and predictor. If the odds ratio is greater than 1, then the odds of success are higher for higher levels of a continuous predictor which means that there is a positive relationship between the dependent variable and the predictor variable or the event would likely to occur, while if the odds ratio is less than 1, then the odds of success are less for higher levels of a continuous predictor which means that there is a negative relationship between the dependent variable and the predictor variable or an event is less likely to occur.

Prior to executing the regression analysis, several diagnostic tests were performed to validate the significance and reliability of both Model 1 (Scenario 1: student accommodation provided by USTP) and Model 2 (Scenario 2: student accommodation provided by a third-party provider). The Likelihood Ratio (LR) Chi-square test confirmed that both Model 1 (p = 0.004) and Model 2 (p < 0.001) were statistically significant, indicating a robust fit over the null model. Model reliability was further verified using the Hosmer-Lemeshow Goodness-of-Fit test; the resulting p-values for Model 1 (p = 0.0821) and Model 2 (p = 0.1026) exceeded the 0.05 threshold, demonstrating that both models adequately fit the empirical data. To ensure the stability of the estimated coefficients, multicollinearity was assessed using Variance Inflation Factor (VIF) analysis. Both models yielded a mean VIF of 1.18, well below the conservative threshold of 5.0, affirming the absence of multicollinearity among the predictors. Lastly, to address potential heteroscedasticity in the survey data and ensure robust statistical inferences, we employed robust standard errors. This approach provided consistent standard error estimates and more reliable p-values even when the constant

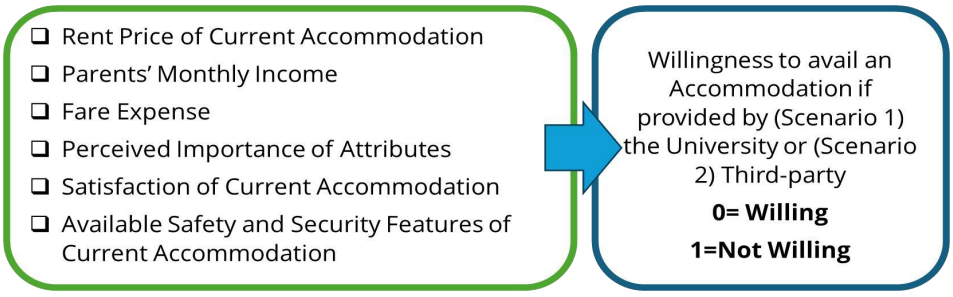


Figure 1. Conceptual Framework of the Study

variance assumption was violated, a common issue in survey-based research [28]. The final analytical sample was comprised of 385 observations. While the analytical sample falls marginally below the computed minimum (n = 390), the difference is minimal (1.3% reduction), and the sample remains substantial for detecting meaningful effects. This exclusion was statistically necessary to ensure model convergence and obtain valid parameter estimates [29].

Ethical Considerations

The study strictly adhered with the Data Privacy Act of 2012 in which the respondents were asked for their consent before participating in the study and were informed that their responses would be treated with complete anonymity and would be used for academic and research purposes only. Furthermore, authorization to conduct the study was sought from and granted by the USTP Office of Student Affairs, ensuring that all institutional protocols for student engagement were fully respected.

RESULTS AND DISCUSSION

Respondent Profile

A total of 461 responses were collected via the distributed Google survey form. As seen in Table 1, the largest portion of respondents was comprised of individuals from the first year (26%) and third year (42%) levels at the University of Science and Technology of Southern Philippines (USTP). Additionally, 68% of the participants came from various cities and municipalities within the Northern Mindanao Region, while those living in Cagayan de Oro city represented only 18% of the total respondents. Only 13% of the total respondents come from the CARAGA, Central Visayas, Davao, BARMM, Soccsargen, and Zamboanga Peninsula regions.

Approximately 42% of participants reported a monthly household income of ₱10,000 or less, which falls below the national poverty threshold of ₱13,873 established by the Philippine Statistics Authority in 2023. An additional 13% of participants were situated near the poverty threshold, with monthly household incomes ranging from ₱10,001 to ₱15,000. Approximately 39% reported monthly family incomes between ₱15,000 and ₱50,000, while only 7% exceeded the ₱50,000 bracket. These financial constraints may expose the majority of students to suboptimal living conditions, compelling them to prioritize affordability and proximity to campus over comfort, safety, and security, as documented in previous research [5, 14, 15, 16].

Only 37% of the respondents resided within barangay Lapasan, Cagayan de Oro city, where USTP is based, while the majority, comprising 61% of the sample size, lived outside the barangay but still within the city limits. This may indicate that student accommodation availability and options within the locality (Brgy. Lapasan), where the university is located, were limited due to the area's existing land use, which is predominantly informal settlements, and medium- to high-intensity commercial uses, thereby forcing students to seek housing elsewhere. The remaining residential areas, particularly repurposed houses near the university converted for student housing, were mostly characterized as informal [21], which presents limitations given that safety and comfortable living conditions are also important factors students consider alongside proximity [30].

In terms of living arrangements, the majority of students were renting, comprising 78%, whereas only 22% were living without charge with relatives or close connections. Additionally, 48% of the participants resided alone in their rooms, whereas only 28% shared their living space with another tenant. A total of 23% of the sample size reported sharing with more than one roommate, while merely 1% indicated sharing a room with over five roommates. The substantial proportion of individuals occupying single-occupancy rooms or accommodation units may suggest a preference for higher levels of privacy over shared spaces with multiple tenants, which offer limited privacy. This finding is corroborated by related studies indicating that students increasingly favor private housing options over communal arrangements [31, 32].

Interestingly, in the era of social media, a significant portion of students, specifically 55% of those surveyed, rely on friends or family to locate suitable accommodations in the city as. In contrast,

only 20% have utilized social media for this purpose. Additionally, 14% secured their housing through walk-ins, while a mere 2% found accommodations via university printed advertisements.

The cost of rent varies depending on the type of accommodation and the facilities and amenities it provides. Based on Table 2, a total of 157 (34%) students opted for room rentals, which had an average cost of P2,423, falling within a price range of P500 to P7,000. In contrast, 68 (15%) students chose to rent bedspaces, averaging P2,219, with prices ranging from P1,000 to P6,000. The solo studio-type apartment or pad emerged as the costliest accommodation option, averaging P4,910, with prices ranging from P2,200 to P10,000, a choice made by 48 (10%) of the respondents. The significant proportion of students (49%) opting for low-cost housing highlights the financial constraints prevalent among the student body. This trend almost aligns with the socioeconomic data discussed previously, which indicates that (42%) of the participants originate from households below the national poverty threshold.

Table 1. Respondents' Profile

Year Level	Frequency (n=461)	%
1st	121	26
2nd	85	18
3rd	193	42
4th	61	13
5th	1	0
Place of Origin		
Caraga Region	31	6.7
Central Visayas	6	1.3
Northern Mindanao (except CDO)	315	68
Davao Region	2	0.4
BARMM	4	
Soccsargen	3	0.9
Zamboanga Peninsula	18	3.9
Cagayan de Oro City	82	18
Estimated Family Income		
P5,000 and below	102	22
P5,001 - P10,000	92	20
P10,001 - P15,000	58	13
P15,001 - P20,000	46	10
P20,001 - P25,000	36	8
P25,001 - P30,000	35	8
P30,001 - P35,000	27	6
P35,001 - P40,000	13	3
P40,001 - P45,000	9	2
P45,001 - P50,000	10	2
P50,001 and above	33	7
Current boarding house or residence location		
Within Brgy. Lapasan, Cagayan de Oro City	170	37
Outside Brgy. Lapasan but within the city	283	61
Outside the city	8	2
Current living arrangement		
Renting	361	78
Living for free	100	22

Table 1 (continued)

Number of students sharing in a room		
Solo	223	48
1	127	28
2	47	10
3	39	8
4	14	3
5	6	1
> 5	5	1
Sources for identifying suitable housing options		
Friend or family	252	55
Social Media	90	20
Walk-in	63	14
Student accommodation agent	21	5
Word-of-mouth or referral	27	6
University Print Advertisements	8	2
Mode of transportation going to school		
Multiple Mode (e.g. jeepney and minibus)	333	72
Motorela	39	8
Personal vehicle	78	17
Walking	11	2

Table 2. Accommodation and Transportation Expenses

Type of rented accommodation	**Freq. (n=461)**	**Rental Price (Php)**		
		Min.	**Max.**	**Ave.**
Room	157	500	7,000	2,423
Bedspace	68	1,000	6,000	2,219
Solo Studio-type apartment/ pad	48	2,200	10,000	4,910
Shared Studio-type apartment/ pad	46	1,500	8,333	3,044
Whole house	15	1,700	6,000	4,400
Shared house	28	375	25,00	1,115
Location		**Transportation Expense (Php)**		
Within Brgy. Lapasan	170	20	50	32
Outside Brgy. Lapasan but within the city	283	20	100	55
Outside the city	8	50	150	80

Available Safety and Security Features

As shown in Figure 2, the survey results reveal substantial deficiencies in essential safety and security features across student accommodations. The most critical gaps include the absence of smoke detection devices (72%), evacuation plans (66%), and fire suppression systems (62%). Additional deficiencies include inadequate setbacks between buildings (50%), missing fire walls between abutting structures (49%), absence of surveillance cameras (48%), non-use of fire-resistive materials (48%), lack of fire exits and wayfinding features (44%), and absence of sidewalks leading to accommodations (41%). The absence of these features poses significant risks, as their effectiveness has been well documented in the literature. Smoke detection devices substantially reduce fire incidences through early detection [33], while fire exits complemented by wayfinding features reduce casualties by facilitating rapid and effective egress [34, 35]. Fire-resistive materials retard flame spread and maintain structural integrity during fires, whereas setbacks and fire walls effectively control fire propagation to adjacent buildings [36]. Properly designed sidewalks complemented by pedestrian

signals and speed tables or marked crossings systematically reduce road crashes [37]. Furthermore, surveillance cameras serve as effective deterrents to criminal activity, with footage providing critical evidence for identifying perpetrators [38]. The identified deficiencies expose students to fires, accidents, theft, and criminal victimization. Stemn et al. [16] attribute inadequate safety features in student housing to landlords' cost-minimization strategies in low-cost housing markets, exacerbated by weak regulatory frameworks, limited government oversight, and insufficient investment in community safety infrastructure.

In contrast to building-specific safety systems, external infrastructure and basic structural features showed higher provision rates, with most students reporting the presence of street lighting (85%), easily navigable and unobstructed hallways and corridors (75%), perimeter fencing (74%), and unobstructed two-way access roads (62%). Additionally, 65% of respondents confirmed that their accommodations were not exposed to flooding or landslide hazards. Nonetheless, the deficiencies in safety and security features identified earlier warrant urgent attention, as inadequate housing conditions can adversely affect students' well-being and academic outcomes. Research indicates that compromised safety and security in student accommodations contribute to poor concentration and focus, reduced attendance and engagement, sleep deprivation, increased stress, diminished academic performance, and ultimately, higher dropout rates [11].

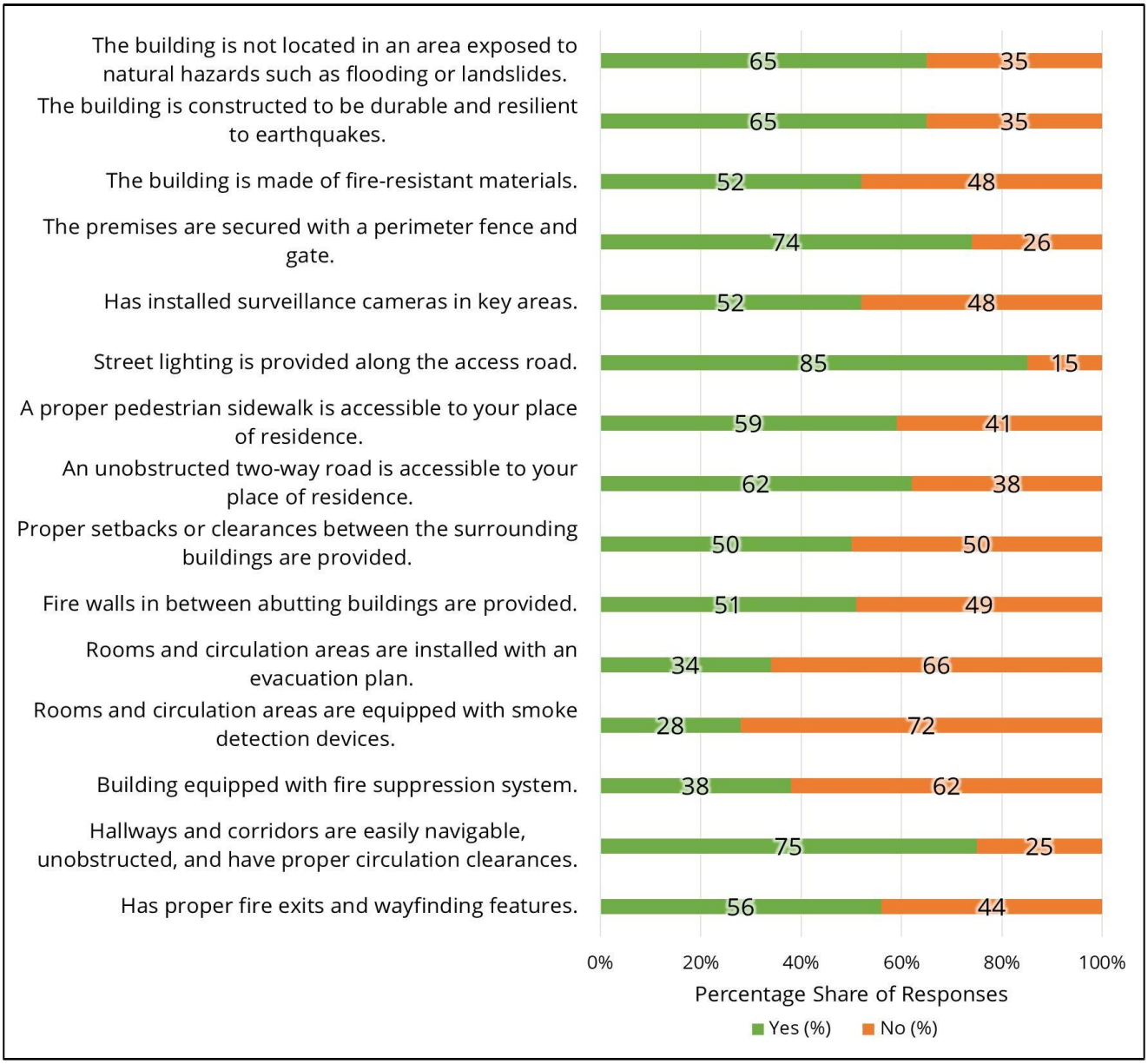


Figure 2. Reported Availability of Safety and Security Features of their Current Accommodations

Student Satisfaction

Satisfaction levels were categorized using weighted mean thresholds: dissatisfied (WM < 2.60), neutral (WM = 2.60–3.39), and satisfied (WM ≥ 3.40). On average, students expressed neutral to satisfied levels of satisfaction with their current accommodations, as shown in Figure 3. Specifically, within the physical environment domain, weighted mean satisfaction ratings for access to residence (WM= 3.28), building design (WM = 3.22), design of living spaces (WM = 3.28), building maintenance (WM = 3.13), cleanliness (WM = 3.25), security (WM = 3.21), learning conduciveness (WM = 3.05), and indoor climate (WM = 3.04) all fell within the neutral range (WM = 2.60–3.39). However, indoor climate and learning conduciveness received the lowest weighted means among all criteria examined, suggesting that a relatively smaller proportion of students experienced optimal conditions in these criteria that merits satisfaction compared to other aspects of their accommodations. Specifically, for indoor climate, 30% of respondents reported dissatisfaction, 32% were neutral, and 35% expressed satisfaction. For learning conduciveness, 35% reported dissatisfaction, 32% were neutral, and 39% expressed satisfaction. These factors are critical, as they influence multiple dimensions of student development and academic success. A study in the United Kingdom found that the lack of control over indoor temperature regulation, particularly during winter and summer seasons in purpose-built student accommodations, negatively impacts students' comfort, well-being, and academic performance [39]. Furthermore, Lukens et al. [40] demonstrated that learning conduciveness, influenced by intentional programmatic design of indoor spaces, can foster holistic social development, enable transformative experiences that equip students with critical skills, and ultimately enhance academic outcomes.

Results in the management area predominantly reflected satisfaction, with weighted means for accommodation contracts (WM = 3.48), policies related to the use of facilities and equipment (WM = 3.53), complaint procedures (WM = 3.45), and curfew (WM = 3.72) all exceeding the 3.40 threshold. While this study did not examine whether third-party providers systematically collect renter feedback, research in Turkey has demonstrated that high satisfaction with dormitory management is linked to the prompt and effective resolution of student concerns facilitated by regular feedback collection and timely data utilization [41]. Curfew policies notably received high satisfaction ratings, with 60% of respondents expressing satisfaction, 25% neutral, and only 16% dissatisfied. Although individual reasons for curfew satisfaction were not explored in this study, several factors may explain these high satisfaction levels found in a number of studies, such as flexible curfew hours in off-campus accommodations. According to Tiwari and Roy [42], flexible curfew policies in off-campus accomodations enable students to manage their own time and exercise greater independence, facilitating increased academic and social participation. Gu and Smith [43] found that students in China opted to live off-campus rather than in university-managed dormitories to gain more freedom, enjoy a less-regulated lifestyle, and maintain greater privacy.

Regarding physical facilities, majority criteria fell within the neutral range, with weighted means for furniture (WM = 3.37), air-conditioning or fan units (WM = 3.31), clothes washing facilities (WM = 3.24), wireless internet speed and reliability (WM = 3.25), and common areas (WM = 3.22). Cooking equipment availability (WM = 3.41) narrowly surpassed the satisfaction threshold (WM = 3.40), indicating borderline satisfactory ratings. Common areas notably elicited the highest proportion of neutral responses (37%) compared to other criteria, with satisfaction and dissatisfaction rates of 37% and 25%, respectively. These findings suggest considerable room for improvements in this domain. Common areas including living spaces, study areas, corridors, and kitchen are crucial for cultivating friendships and fostering a sense of community within student accommodations [44, 45]. These spaces serve as transitional environments where residents exchange ideas, experiences, and cultural perspectives, thereby reducing individual loneliness and anonymity [40]. Furthermore, research on international students in Australian private-sector accommodations found that overcrowding, poor conditions of shared spaces, and the conversion of common areas into additional bedrooms hindered comfortable social interaction, potentially leading to loneliness and social isolation [46]. Beyond social considerations, inadequate design of common-use spaces and furniture can lead to negative long-term health effects, including poor posture and musculoskeletal disorders (MSDs), which

can be mitigated through the application of anthropometric and ergonomic design principles [47].

Weighted means for hygiene and utilities criteria showed mixed results. Utility-related criteria demonstrated satisfactory ratings: availability of proper lighting (WM = 3.65), electrical sockets (WM = 3.59), and electricity stability (WM = 3.80). The relatively high satisfaction with electrical power stability compared to other criteria was likely attributable to the stable electricity supply in the Mindanao region during the study period [48]. While power supply conditions are determined at a regional scale, maintaining power reliability is essential, as substantial power outages cause students to miss lectures, limit access to learning resources, and hinder assessment completion, often leading to increased stress, anxiety, and feelings of isolation [49]. Conversely, potable water supply stability (WM = 3.35) received neutral ratings, likely reflecting the local water district's long-term intermittent service, compounded by low water quality, illegal connections, and damaged infrastructure [50, 51]. Hygiene-related

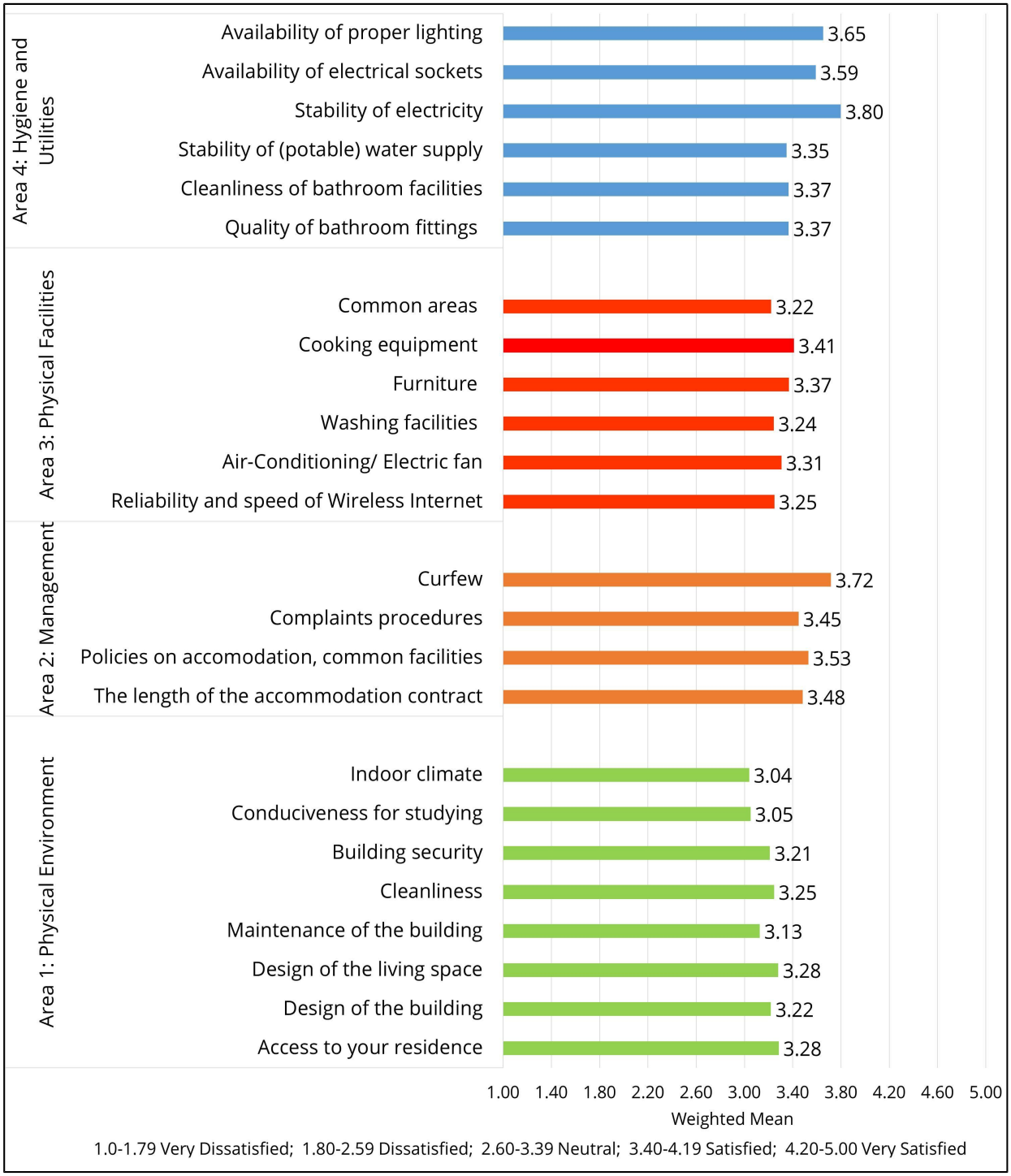


Figure 3. Weighted Mean of Students' Satisfaction Levels of their Current Accommodations.

criteria, cleanliness of bathroom facilities (WM = 3.35) and quality of bathroom fittings (WM = 3.35) also fell within the neutral range, indicating room for improvements. These finding warrants attention, as poor toilet hygiene facilitates the transmission of pathogenic bacteria and viruses, including Salmonella and SARS-CoV-2 [52]. Improvements can be achieved through regular cleaning and disinfection protocols, proper flushing mechanisms, hand hygiene promotion, and efficient ventilation systems to control odor and humidity levels [52].

Overall, 17 criteria (71%) fell within the neutral range, while only 7 (29%) received satisfactory weighted means from respondents. This suggests that, within the context of their current student accommodations, conditions may be insufficient to elicit positive responses yet not poor enough to provoke dissatisfaction. However, neutrality may reflect other factors, including respondents' hesitancy to express definitive opinions, indifference, or considerations not explored in this study [53]. Research indicates that neutral responses may serve as an "escape option," particularly for socially sensitive questions [54]. Consequently, high proportions of neutral responses present interpretive challenges for organizations such as universities, as they provide ambiguous guidance for identifying issues and determining necessary improvements to enhance end-user experience [55]. Nevertheless, neutral ratings may also signal opportunities for enhancement to optimize satisfaction levels in student accommodations [56].

Students Perceived Importance of Student Accommodation Attributes

Analysis of responses in Figure 4 revealed that the attributes students perceived as most important (top tier attributes) in student accommodations, with at least 80% endorsement, were: stable electricity (85%), stable water source (84%), safety (83%), cleanliness (83%), availability of internet connectivity (82%), provided bathroom facilities (81%), privacy (81%), and conducive indoor climate (81%). The prominence of attributes related to physiological and safety requirements including utilities, hygiene, safety, and shelter aligns with Maslow's hierarchy of needs, which posits that these fundamental needs must be satisfied for survival and personal protection before individuals can pursue higher-level needs such as love and belonging, self-esteem, and self-actualization [23]. A research in Ghana similarly found that utilities such as lighting and water were primary determinants of students' accommodation choices [16]. However, students' sensitivity to rental costs and limited viable housing options often compel them to compromise safety and security in favor of more affordable off-campus accommodations [16]. Notably, the high percentage share for internet connectivity reflects its emergence as an essential resource in 21st-century education, particularly for conducting academic research [57, 58] and facilitating online learning, a necessity underscored during the COVID-19 pandemic when it became indispensable for remote instruction [59]. Furthermore, the high importance placed on privacy was consistent with Beder and Imamoğlu [60], which established that low occupant and room density are positively correlated with residential satisfaction, underscoring students' preference for enhanced privacy.

Attributes that received 70–79% endorsement (second tier attributes) included low noise levels (79%), quality of construction (77%), construction materials used (76%), storage for personal items (76%), availability of a study area (75%), management and maintenance (75%), provision of a cooking area (75%), road accessibility (74%), proximity to campus (74%), and rental price (70%). The high endorsement of low noise levels (79%) underscores acoustic comfort's role in cognitive performance, as research demonstrates that high noise levels negatively affect reading comprehension [61] and contribute to auditory problems and reduced concentration among students [62]. Research in Nigeria identified structural quality as a key determinant of student housing satisfaction, alongside functional and aesthetic qualities [63]. Similarly, a study in China found that common facilities such as lounges, study rooms, and kitchens serve as important environmental factors for informal learning experiences, enabling students to learn independently and collaboratively outside classroom settings [64]. Rental price and proximity to campus received endorsement rates of 70% and 74%, respectively lower than safety (83%). This pattern appears to contradict research identifying affordability and proximity as primary drivers of student accommodation choices [16,57]. However,

this discrepancy likely reflected the distinction between stated preferences (what students ideally want) and revealed preferences (what actually drives their choices). When asked to rate importance, students may emphasize aspirational attributes such as safety and quality, yet in practice, financial constraints force them to prioritize affordability. This gap between stated and revealed preferences is well-documented in housing choice literature, where budget constraints compel compromises between desired and attainable housing qualities [65, 66]

Attributes that received 60% - 69% endorsement (third tier attributes) included interior design of the building (69%), number of roommates (68%), availability of a lounge area (67%), proximity to open spaces (66%), proximity to malls (64%), and exterior design of the building (60%). These findings aligned with research indicating that students often compromise on aesthetics, facility quality, occupant density, and proximity to social amenities to secure affordable housing [57, 66]. This pattern was likely attributable to the financial constraints of the majority of respondents, with 55% reporting monthly household incomes of ₱15,000 or below. Magni et al. [15] similarly found that proximity to services such as laundromats (65%) and commercial establishments was considered less important than rental cost. Furthermore, research demonstrated that proximity to services and commercial establishments, particularly shopping centers, commands premium rental and housing prices [67, 68, 69], which may be unaffordable for financially constrained students.

Attributes that received the lowest endorsement rates relative to previously mentioned attributes (fourth tier) included accessibility features for individuals with physical disabilities (55%), proximity to a library (53%), availability of parking space (48%), gym or exercise facilities (46%), and provision of sports facilities (40%). The limited endorsement of wellness and recreation facilities (40%-46%), while noteworthy given their importance for sustaining students' mental and physical well-being, may reflect the additional membership and subscription fees these amenities typically require [57]. The relatively low prioritization of accessibility features for persons with disabilities (PWD) (55%) by the respondents may suggest implicit biases, including ableism [70]. This pattern potentially reflected ablecentrism and universal design apathy worldviews characterized by the prioritization of able-bodied experiences and indifference toward universal accessibility which may indicate insufficient awareness and education regarding the daily challenges PWD students face in accessing educational and residential facilities [71, 72]. Notably, library proximity received limited endorsement (53%), likely reflecting multiple factors. First, the proliferation of digital resources accessible from any location has reduced dependence on physical library collections [73, 74]. Second, the normalization of remote learning during COVID-19 demonstrated the viability of distance-based academic work [59]. Additionally, the availability of alternative study spaces has diminished the need for library proximity [75].

The hierarchy of students' perceived importance of student accommodation attributes revealed critical implications for policy frameworks and institutional planning. Students overwhelmingly endorsed fundamental utilities reflecting Maslow's foundational needs hierarchy [23]. Critically, limited financial resources may compel students to compromise safety, aesthetics, and amenities for affordability, highlighting the urgent need for policies addressing student housing affordability and supply. These findings indicate that effective student accommodation policy must establish enforceable minimum standards for utilities, safety, and environmental quality while simultaneously addressing affordability barriers and ensuring inclusive, holistic support for diverse student needs beyond mere shelter provision.

Willingness to Pay and Binary Logistic Regression Results

This study employed two hypothetical scenarios to examine students' accommodation preferences. Scenario 1 presented a university-provided four-story dormitory building located on campus, housing 33 rooms with a total capacity of 132 students. Each 21-square-meter room accommodated four students and included a private toilet and bath, study area, and closet. Common facilities included a lobby, ground-floor commercial spaces, laundry area, communal kitchen, shared

study area, and parking area. Safety features included CCTV surveillance and a fire suppression system. Scenario 2 presented an accommodation with identical specifications and amenities, but provided by a third-party institution located off-campus. This parallel design isolated the effect of location (on-campus vs. off-campus) and provider type (university vs. third-party) while holding accommodation quality constant, which enabled direct comparison of how these factors influence student choice.

Table 3 demonstrated that 61% of students were willing to pay only ₱1,500 or less per month for

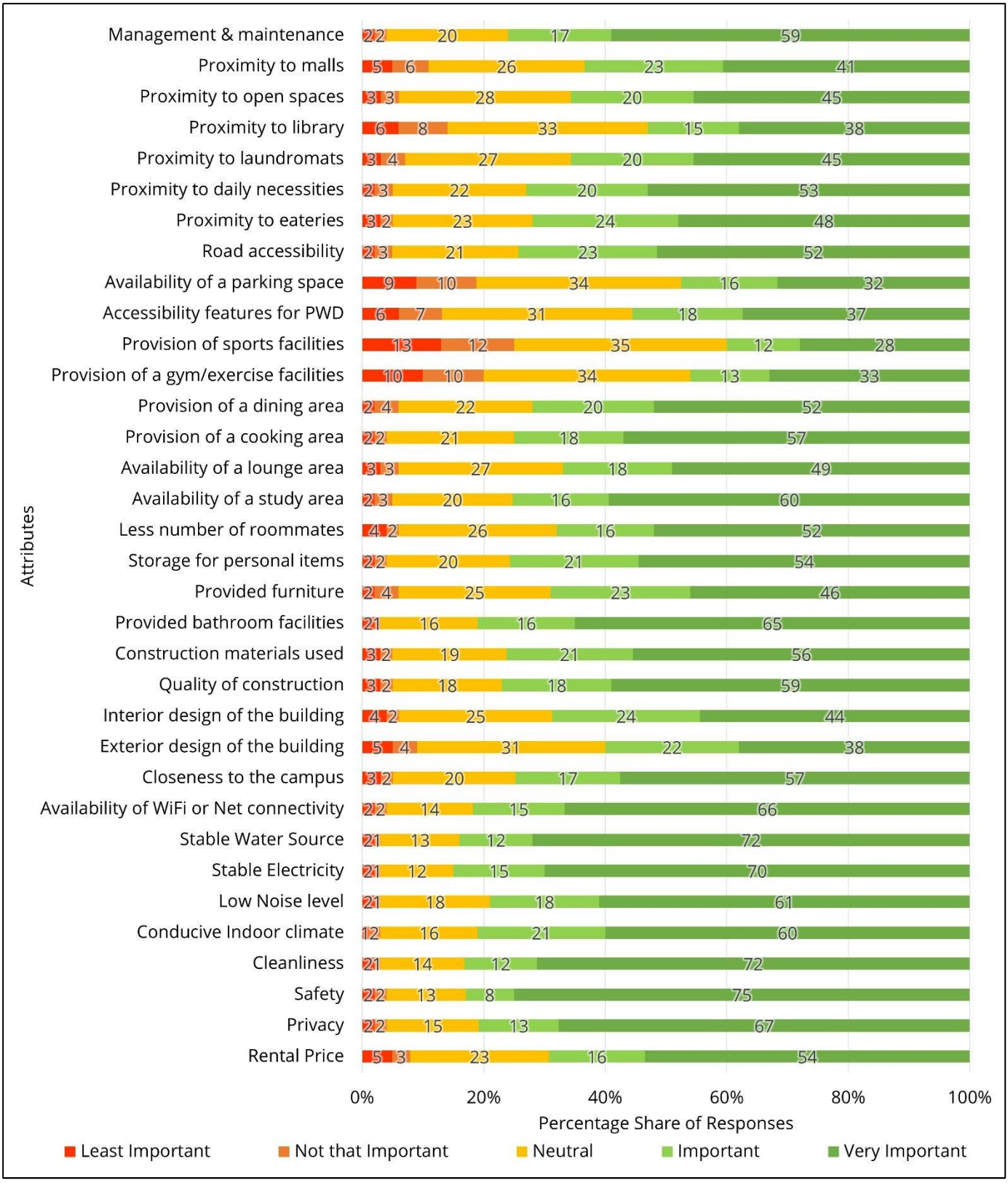


Figure 4. Perceived Importance of Accommodation Attributes

four-person shared accommodation, compared to 39% willing to pay ₱2,500 or more. This preference for budget-friendly options reflected not merely economic choice but financial necessity, particularly among the 55% of respondents with household incomes ≤₱15,000. Without institutional support mechanisms, such economic constraints force students into a documented pattern of compromise, sacrificing comfort, convenience, safety, and social well-being for affordability with cascading negative effects on academic performance and overall student success [5,11, 15, 16, 57, 67]. These findings provide compelling evidence for institutional intervention through expanded on-campus accommodation to support students with less financial capacity to afford conducive housing.

Following the established scenarios, the participants were subsequently queried about their willingness to consider student accommodation under two specified cases, as stated in Table 4. The table presents the results of logistic regression based on two hypothetical scenarios. The output reports the odds ratio (OR), and the robust standard error enclosed in parentheses.

The first scenario examined students' likelihood of choosing university-provided accommodation located on campus. The chi-square test indicated that this model represents a significant improvement in fit relative to an intercept-only model ($p < 0.01$). Two variables significantly predicted students' likelihood of selecting on-campus accommodation: transportation fare expenses and current accommodation satisfaction. Specifically, the likelihood of choosing on-campus accommodation increases by a factor of 1.0124 ($p = 0.033$) with each peso increase in transportation fare expenses. This reflected students' price sensitivity to transportation costs, which function as a combined weighted measure of time, distance, and other travel-related variables [26]. Multiple studies have documented students' preference for minimizing transportation costs, travel distance, and travel time to campus, as well as the negative effects of long commutes on academic performance [4, 57, 77, 78].

Conversely, satisfaction with current accommodation negatively predicted likelihood of choosing on-campus housing (OR = 0.6654, $p = 0.009$). Since USTP had no on-campus accommodation at the time of the study, this variable reflects satisfaction with current off-campus housing provided by third-party landlords. In other words, students already satisfied with their off-campus accommodation would be less likely to relocate to on-campus housing. This resistance likely stems from benefits associated with off-campus living, including greater independence, flexible curfew policies, adaptable living arrangements, diverse accommodation types offering varying degrees of privacy, and potentially lower rental costs [42, 43, 79, 80, 81].

The second scenario examined students' likelihood of selecting accommodation provided by a third-party institution located off-campus. The model demonstrated significant improvement over the intercept-only baseline ($p < 0.01$), consistent with Scenario 1. Three predictor variables achieved significance: parents' monthly income (OR = 1.00, $p = 0.009$), current accommodation satisfaction (OR = 0.5243, $p < 0.001$), and the availability of safety and security features in current accommodation (OR = 1.0121, $p = 0.010$).

The odds ratio for parents' monthly income equaled 1.00 ($p = 0.009$), presenting a puzzling finding: while statistically significant, the null odds ratio indicated no net directional effect on selection likelihood. The significance suggested income played a role in accommodation choice, though not captured by the linear specification. This warrants further investigation, particularly examining whether income moderates the effects of other predictors such as safety features or satisfaction [82].

Current accommodation satisfaction demonstrated a strong negative relationship with selection likelihood (OR = 0.5243, $p < 0.001$), consistent with Scenario 1. Each unit increase in satisfaction reduced the odds of selecting the proposed accommodation by approximately 48%. This pattern reflects the comparative advantages of off-campus living, including greater autonomy, flexible policies, and diverse accommodation options which may outweigh proximity benefits for students already satisfied with their current arrangements. Research confirmed that accommodation satisfaction influences residential loyalty [83, 84]. Conversely, students dissatisfied with their current accommodation demonstrated higher propensity to relocate, likely driven by deficiencies in indoor climate,

comfort, and safety documented in off-campus housing by this study and previous research [7, 83].

The available of safety and security features demonstrated a positive relationship with selection likelihood (OR = 1.0121, p = 0.010), indicating that each percentage point increase in the availability of safety features in current accommodation raised the odds of selecting the proposed accommodation by 1.21%. This finding appeared to contradict previous research identifying rental affordability as the primary determinant overriding safety concerns [14,15,16]. However, this result should not be discounted, as compromised safety and security contribute to poor concentration, reduced attendance, sleep deprivation, increased stress, diminished academic performance, and higher dropout rates [11].

Table 3. Students' Willingness to Pay Price for a Proposed 4-Person Capacity Room Dormitory.

Willingness to Pay Price	Frequency	%
Less than 1,500	134	29
P 1,500	149	32
P 2, 500	117	25
P 3, 500	38	8
P 4, 500	10	2
P 5,500	5	1
More than P 5,500	8	2

Table 4. Results of the Logistic Binary Regression.

Dependent Variable:
Willing to avail a student dorm: Yes = 1, No = 0

Regression Variables	Scenario 1: Student accommodation is provided by USTP and is located inside the campus.	Scenario 2: Student accommodation is provided by 3rd party located outside the campus.
Constant	31.3380***	4.0369**
	(23.2691)	(2.5057)
Rent Price of Current Accommodation	0.9999	1.000
	(0.0001)	(0.0001)
Parents Monthly Income	0.9999	1.000***
	(9.16e-06)	(8.93e-06)
Fare Expense	1.0124**	0.9980
	(0.0060)	(0.0051)
Perceived Importance of Accommodation Attributes	0.7596	1.0638
	(0.1252)	(0.1531)
Satisfaction of Current Accommodation	0.6654***	0.5243***
	(0.1035)	(0.0760)
Available Safety and Security Features of Current Accommodation	1.0064	1.0121***
	(0.0053)	(0.0048)
N	385	385
prob > chi2	0.0012***	0.0001***

*Note: **, *** Indicate significance at the 95%, 99% level, respectively; ( ) Indicate Robust standard error*

CONCLUSION

A substantial body of literature has attested to the importance of student accommodation for students' overall well-being and academic performance, with significant implications for safety, housing security, and financial stability. Consequently, examining students' socioeconomic profiles, available safety and security features, satisfaction levels with current accommodations, perceived importance of accommodation attributes, and factors influencing accommodation choice is crucial for identifying areas where universities can provide effective interventions.

Critically, this study identified that approximately 55% of USTP Cagayan de Oro participants reported monthly household incomes of ≤₱15,000—within the margins of the ₱13,873 poverty threshold established by the Philippine Statistics Authority in 2023. This financial vulnerability may compel students to accept unconducive and unsafe housing options to secure affordable rents despite their compromised quality. Furthermore, through student self-reported assessments and satisfaction ratings, the study documented substantial deficiencies in safety and security features in off-campus accommodations, particularly critical fire safety infrastructure (smoke detection devices, evacuation plans, fire suppression systems, setbacks, and firewalls), alongside neutral ratings across 71% of evaluated criteria, particularly indoor climate and learning conduciveness. These findings underscore the urgent need for improvement through establishment of minimum standards and regulatory oversight to ensure safety, livability, and learning conduciveness across all student accommodation types, whether provided by SUCs or third-party landlords.

This study also identified a hierarchical structure of important accommodation attributes through participants' rated perceived importance: first-tier attributes (utilities, safety, and hygiene), second-tier attributes (building integrity, common areas, rental price and academic considerations), third-tier attributes (aesthetic and lifestyle considerations), and fourth-tier attributes (specialized facilities). This evidence-based hierarchy provides guidance for university administrators, architects, and designers regarding which student accommodation features and facilities to provide and prioritize. Additionally, the logistic regression findings confirm that transportation costs, current accommodation satisfaction, and safety feature availability significantly predict accommodation choices, providing empirical support for university investment in on-campus housing as a mechanism to reduce commuting burdens, ensure safety standards, improve living conditions, and support students from low-income families.

Although this study provides extensive insights into multiple aspects of student accommodation, several methodological limitations warrant acknowledgment. First, the use of non-probability convenience sampling, specifically employing voluntary response methods through online surveys, and the study's exclusive focus on USTP Cagayan de Oro students may limit generalizability. Future studies should employ stratified sampling across multiple institutions with diverse characteristics (public/private, urban/rural, with/without existing on-campus housing) to enhance generalizability. Second, reliance on student self-reports for assessing accommodation characteristics may introduce recall bias, social desirability bias, and limitations stemming from students' technical knowledge. Future research should incorporate validation through follow-up interviews and independent on-site inspections using standardized checklists. Lastly, while the hypothetical scenarios successfully identified determinants of student choice, the method did not capture factors associated with diverse student accommodation types varying in features, rental prices, and distances from campus. Future studies should devise methods that explore these considerations to extend beyond the contributions of this study.

Author Contributions: Conceptualization, AG Wabe, along with GAC Babanto. Data Collection: AG Wabe. Data Processing and Analysis: GAC Babanto. Writing, review, and editing: AG Wabe and GAC Babanto.

Funding: This research received no external funding.

Data Availability Statement: Data supporting this study cannot be made available due to ethical restrictions. The research is bound under Data Privacy Act of 2012.

Acknowledgments: The authors acknowledge the Office of Student Affairs (OSA) at the University of Science and Technology of Southern Philippines, Cagayan de Oro Campus for approving the survey to currently enrolled students during the 1st Semester of school year 2023-2024. Additionally, the authors thank the University Student Council and Architecture Students for assisting with the distribution of the online survey.

Conflicts of Interest: The authors declare no conflicts of interest. Funders had no input in how the study was designed, how the data was gathered, analyzed, interpreted, how the article was written, or whether the findings were published.

REFERENCES

1. Neuman, D. Building Type Basics for College and University Facilities, 2nd Edition. **2013**.
2. Kim, W. Effects of Physical Living Environment on the Social Interaction and Perceived Sense of Community among Students in University Dormitory. *The Journal of Korean Institute of Educational Facilities* **2015**, *22* (5), 3–10. https://doi.org/10.7859/KIEF.2015.22.5.003.
3. de Araujo, P.; Murray, J. M. Estimating the Effects of Dormitory Living on Student Performance. *Labor: Human Capital eJournal* 2010. https://doi.org/10.2139/ssrn.1555892.
4. Balabanian, B. Transportation and Its Effect on Student Performance. *Department of Physical Geography and Ecosystem Science Lund University* **2020**.
5. Brilliantes, R. A.; Aga, N. B.; Adegue, C. I. A.; Perez, M. P.; Aya-ay, A. M.; Sagarino, E. V. The Living Conditions of University Students in Boarding Houses and Dormitories in Davao City, Philippines. *IAMURE International Journal of Social Sciences* **2012**, *1* (1).
6. Amole, D. Residential Satisfaction in Students' Housing. *Journal of Environmental Psychology* **2009**, *29*, 76–85. https://doi.org/https://doi.org/10.1016/j.jenvp.2008.05.006.
7. Johnson, E.; Cole, E.; Merrill, R. Environmental Health Risks Associated with Off-Campus Student-Tenant Housing. *J Environ Health* **2009**, *71* (6), 43–49.
8. Yildirim, K.; Uzun, O. The Effects of Space Quality of Dormitory Rooms on Functional and Perceptual Performance of Users: Zübeyde Hanım Sorority. *Gazi University Journal of Science* **2010**, *23*.
9. Paltridge, T.; Mayson, S.; Schapper, J. The Contribution of University Accommodation to International Student Security. *Journal of Higher Education Policy and Management* **2010**, *32* (4), 353–364. https://doi.org/10.1080/1360080X.2010.491109.
10. Mogenet, J. L.; Rioux, L. Students' Satisfaction with Their University Accommodation. *Nordic Psychology* **2014**, *66* (4), 303–320. https://doi.org/10.1080/19012276.2014.982441.
11. Franzoi, I. G.; Carnevale, G.; Sauta, M. D.; Granieri, A. Housing Conditions and Psychological Distress among Higher Education Students: A Systematic Literature Review. *Journal of Further and Higher Education* **2022**, *47*, 229–241. https://doi.org/10.1080/0309877X.2022.2102416.
12. Marasinghe, S. A.; Sun, Y.; Norbäck, D.; Adikari, A. M. P.; Mlambo, J. Indoor Environment in Sri Lankan University Dormitories: Associations with Ocular, Nasal, Throat and Dermal Symptoms, Headache, and Fatigue among Students. *Building and Environment* **2024**. https://doi.org/10.1016/j.buildenv.2024.111194.
13. Nijënstein, S.; Haans, A. A.; Kemperman, A.; Borgers, A. Beyond Demographics: Human Value Orientation as a Predictor of Heterogeneity in Student Housing Preferences. **2015**.
14. Forbes-Mewett, H. International Student Housing Security. **2018**, 135–164. https://doi.org/10.1057/978-1-137-59102-9_6.
15. Magni, M.; Pescaroli, G.; Bartolucci, A. Factors Influencing University Students' Accommodation Choices: Risk Perception, Safety, and Vulnerability. https://doi.org/10.1007/s10901-019-09675-x.

16. Stemn, E.; Koomson, E.; Fosu, S. Determinants of University Students' Choice of Accommodation: An Analysis of Risk Perception and Safety Awareness. **2024**. https://doi.org/https://doi.org/10.1007/s10901-024-10162-1.
17. Universal Access to Quality Tertiary Education Act, R.A.10931 (2017). https://lawphil.net/statutes/repacts/ra2017/ra_10931_2017.html
18. Orbeta, A.; Lagrada-Sinha, L.; Corpus, J. Assessing the Republic Act 10931 or the Universal Access to Quality Tertiary Education Act. *PIDS Discussion Paper Series* **2019**, No. No. 2019-14.
19. Maceda, E. M. Lack of Dorms. *The Philippine Star* **2015**.
20. Senate of the Philippines. Lapid Wants to Establish a Student Housing Registry in Every City and Municipality in the Country. **2019**.
21. Naelga, S. C.; Eulogio, D.; Branzuela, N. F.; Dumaog, A. C.; Ecalina, C. L.; Espinosa, L. D. An Assessment of the Quality of Houses and Households in Sitio Lawesbra, Lapasan Cagayan de Oro City: An Extension Program, Mindanao, Philippines. *Nexo Scientific Journal* **2021**, *34* (01). https://doi.org/10.5377/nexo.v34i01.11294.
22. Department of Social Welfare and Development. DSWD DROMIC Report #1 on the Fire Incident in Brgy. Lapasan, Cagayan de Oro City, Misamis Oriental. **2023**.
23. Maslow, A. H. Motivation and Personality. **1954**.
24. Stiglitz, J. E.; Walsh, C. E. Principles of Microeconomics. **2006**.
25. Samuelson, P. A. Foundations of Economic Analysis. **1947**.
26. Alonso, W. Location and Land Use. Toward a General Theory of Land Rent. 1964. https://doi.org/10.4159/harvard.9780674730854.
27. McFadden, D.; Richter, M. K. Stochastic Rationality and Revealed Preference. *Preferences, Uncertainty, and Optimality: Essays in Honor of Leo Hurwicz* **1990**, 161–186.
28. White, H. A Heteroskedasticity-Consistent Covariance Matrix Estimator and a Direct Test for Heteroskedasticity. *Econometrica* **1980**, *48* (4), 817–838. https://doi.org/https://doi.org/10.2307/1912934.
29. Albert, A.; Anderson, J. A. On the Existence of Maximum Likelihood Estimates in Logistic Regression Models. Biometrika 1984, 71 (1), 1–10. https://doi.org/10.1093/biomet/71.1.1.
30. Agriansyah, A. Pengaruh Harga, Lokasi, Keamanan, Kenyamanan, Dan Fasilitas Terhadap Minat Sewa. *Jurnal Manajemen Pemasaran Dan Perilaku Konsumen* **2024**, *3* (4), 1072–1080. https://doi.org/10.21776/jmppk.2024.03.4.21.
31. Kim, M.-K.; Jang, E.-H. Satisfaction and Preference of Private and Shared Space of Student Housing for One Person Household - Focused on the University Students in Cheongju, Chungbuk - . *Korean Journal of Human Ecology* **2011**, *20* (5), 1059–1074. https://doi.org/10.5934/KJHE.2011.20.5.1059.
32. Verhetsel, A.; Kessels, R.; Zijlstra, T.; Van Bavel, M. Housing Preferences among Students: Collective Housing versus Individual Accommodations? A Stated Preference Study in Antwerp (Belgium). *Journal of Housing and The Built Environment* **2017**, *32* (3), 449–470. https://doi.org/10.1007/S10901-016-9522-5.
33. Gilbert, S. W. Estimating Smoke Alarm Effectiveness in Homes. **2021**. https://doi.org/10.1007/s10694-020-01072-z.
34. Jeon, G.-Y.; Na, W.-J.; Hong, W.-H.; Lee, J.-K. Influence of Design and Installation of Emergency Exit Signs on Evacuation Speed. *Journal of Asian Architecture and Building Engineering* **2019**, *18* (2), 104–111. https://doi.org/10.1080/13467581.2019.1599897.
35. Bernardini, G.; Lovreglio, R.; Quagliarini, E.; D'Orazio, M. Can Active and Passive Wayfinding Systems Support Fire Evacuation in Buildings? Insights from a Virtual Reality-Based Experiment. *Journal of Building Engineering* **2023**, *74*, 106778. https://doi.org/10.1016/j.jobe.2023.106778.
36. Buchanan, A. H.; Abu, A. K. Structural Design for Fire Safety. 2017.
37. Sharma, S. N.; Dehalwar, K. A Systematic Literature Review of Pedestrian Safety in Urban Transport Systems. **2025**. https://doi.org/https://doi.org/10.33492/JRS-D-25-4-2707507.
38. La Vigne, N. G.; Lowry, S. S.; Markman, J. A.; Dwye, A. M. Evaluating the Use of Public Surveillance Cameras for Crime Control and Prevention–A Summary. **2011**.

39. Marsh, A. Thermal Comfort and Air Quality Control in UK Student Accommodation Understanding the Interactions between Heating and Ventilation Systems, Occupant Experience, and Indoor Environmental Conditions. **2021**.
40. Lukens, A.; Firmin, S.; Broadhurst, C. The Impact of Residential Life on the Development of Long-Term Relationships in Higher Education. *College Student Affairs Journal* **2022**, *40* (2), 107-120.
41. Altinay, Z.; Arslan, R. U.; Sharma, R. C. Assessing Student Satisfaction and Institutional Efficiency in Dormitory Management: A Qualitative Analysis Based on Student Perspectives. *Sustainability* **2024**, *16* (20), 8823. https://doi.org/10.3390/su16208823.
42. Tiwari, D.; Roy, U. K. The Safety Premium: Gendered Costs and Control in Student Housing in Dehradun. *Urban Matters Journal* **2025**.
43. Gu, H.; Smith, D. P. 'Living off the Campus': Urban Geographies of Change and Studentification in Beijing, China. *Urban Geography* **2020**, *41* (2), 205-224. https://doi.org/10.1080/02723638.2019.1659071.
44. Heasley, C.; Boone, K.; Davidson, D. L. Empirical Comparison of Sense of Community Outcomes for Students in Campus Halls and Public-Private Partnership Developed Housing. *The Journal of College and University Student Housing* **2020**.
45. Dailey, S. L.; Dean, S. R. Understanding Students' Experiences in a STEM Living-Learning Community. *The Journal of College and University Student Housing* **2020**.
46. Morris, A.; Mitchell, E.; Wilson, S.; Ramia, G.; Hastings, C. Loneliness within the Home among International Students in the Private Rental Sector in Sydney and Melbourne. **2021**, 67-81. https://doi.org/https://doi.org/10.1080/08111146.2021.2005017.
47. Bai, Y.; Kamarudin, K. M.; Alli, H. A Systematic Review of Research on Sitting and Working Furniture Ergonomic from 2012 to 2022: Analysis of Assessment Approaches. *Heliyon* **2024**, *10* (7), e28384.
48. Colina, A. I. DOE Exec Sees Stable Mindanao Power Supply amid El Niño. *Manila Bulletin* **2023**.
49. Thembane, N. Navigating the Power Outages: Impact and Coping Strategies of Students in a South African University during Loadshedding. *Journal of Student Affairs in Africa* **2024**, *12* (1). https://doi.org/https://doi.org/10.24085/jsaa.v12i2.4643.
50. Cimene, F. T. A.; Eupeña, R. G.; Elayan, J. M.; Napitan, H. M. C. B.; Nacaya, I. M. Q. Analysis on Water Sufficiency and Its Policy Implications: The Case of a Highly Urbanized City in Southern Philippines. **2022**.
51. Rosete, F. D. Cagayan de Oro Households Demand Water District to Solve Water Supply Problem. *Manila Bulletin* **2023**.
52. Abney, S. E.; Bright, K. R.; McKinney, J.; Ijaz, M. K.; Gerba, C. P. Toilet Hygiene - Review and Research Needs. *Journal of Applied Microbiology* **2021**, *131* (6), 2705-2714. https://doi.org/10.1111/JAM.15121.
53. Smrke, U.; Blenkuš, M.; Sočan, G. Residential Satisfaction Questionnaires: A Systematic Review. *Urbani Izziv* **2018**, *29* (2), 67-82. https://doi.org/https://doi.org/10.5379/URBANI-IZZIV-EN-2018-29-02-001.
54. Kankaraš, M.; Capecchi, S. Neither Agree nor Disagree: Use and Misuse of the Neutral Response Category in Likert-Type Scales. *Metron-International Journal of Statistics* **2024**. https://doi.org/https://doi.org/10.1007/s40300-024-00276-5.
55. Pawson, H.; Pawson, H.; Sosenko, F. Tenant Satisfaction Assessment in Social Housing in England: How Reliable? How Meaningful? *International Journal of Consumer Studies* **2012**, *36* (1), 70-79. https://doi.org/10.1111/J.1470-6431.2011.01033.X.
56. Gong, A.; Söderberg, B. Residential Satisfaction in Student Housing: An Empirical Study in Stockholm, Sweden. *Journal of Housing and the Built Environment* **2023**, *39* (3), 537-555. https://doi.org/10.1007/s10901-023-10089-z1.
57. Ike, N.; Baldwin, C.; Lathouras, A. Tertiary Students' Housing Priorities: Finding Home Away from Home. *Canadian Journal of Urban Research* **2020**, *29* (1), 55-69.
58. Abusailan, A.; Abatayo, A. V. Caught in the Slow Lane: Effects of Unstable Internet Connectivity on Accessing Academic Resources and Collaborative Learning. **2024**, *2* (9). https://doi.org/10.69569/jip.2024.0370.

59. Flores, W. Educación Virtual y Conectividad En Estudiantes Universitarios Durante La Pandemia Del COVID-19: Un Estudio de Investigación En Lima. *Latam* **2024**, *5* (4). https://doi.org/10.56712/latam.v5i4.2422.
60. Beder, D.; Imamoğlu, Ç. Correlates of Dormitory Satisfaction and Differences Involving Social Density and Room Locations. *Journal of Housing and the Built Environment* **2023**, *3*. https://doi.org/10.1007/s10901-023-10040-21.
61. Diaco, S. B. Effects of Noise Pollution in the Learning Environment on Cognitive Performances. *Liceo Journal of Higher Education Research* **2014**, *10* (1). https://doi.org/https://doi.org/10.7828/LJHER.V10I1.655.
62. Ibrahim, S. A. J. Reviewing the Effects of Noise Pollution on Students (College and University). *AIP Conference Proceedings* **2023**, *2591* (1). https://doi.org/10.1063/5.0121878.
63. Akinluyi, M. L. An Evaluation of Functional, Aesthetic, Structural Qualities and Satisfaction in Selected Students' Housing for the University. **2015**, *3* (1), 1-27.
64. He, W.; Zeng, N. The Relationship Between University Dormitory Environmental Factors and Students' Informal Learning Experiences: A Case Study of Three Universities in Guangdong Province. *Buildings* **2025**, *15* (14), 2518. https://doi.org/10.3390/buildings15142518.
65. Sadayuki, T. Uncertainty in a College-Town Housing Market: The Case of the University of Illinois at Urbana- Champaign. *The Journal of College and University Student Housing* **2015**, *41* (2), 78-97.
66. McCartney, S.; Rosenvasser, X. Affordability Is King-with Private Bedroom: Exploring the Mismatch of Students' Housing Preferences in Constrained Housing Markets. *Housing Studies* **2023**, 1-21. https://doi.org/10.1080/02673037.2023.2224252.
67. Shimizu, C.; Yasumoto, S.; Asami, Y.; Clark, T. N. Do Urban Amenities Drive Housing Rent. *Research Papers in Economics* **2014**.
68. Zhang, Z. The Price Premium for Properties near Shopping Centers: Evidence from China. **2019**, 393-397. https://doi.org/https://doi.org/10.2991/HSMET-19.2019.72.
69. Villada-Medina, H. D. Efecto de Los Centros Comerciales En El Precio de La Vivienda: El Caso de Medellín. *Anales de Geografía de La Universidad Complutense* **2023**, *43* (2), 555-573. https://doi.org/10.5209/aguc.90588.
70. Efendioğlu, K.; Öksüz, E. E. Engellilere Yönelik Örtük Tutumlar. *Çukurova Üniversitesi Sosyal Bilimler Enstitüsü Dergisi* **2023**. https://doi.org/https://doi.org/10.35379/cusosbil.1295030.
71. Powell, J. J. W. From Ableism to Accessibility in the Universal Design University. *The Review of Disability Studies: An International Journal* **2012**, *8* (4).
72. Terry, G.; Anstiss, D.; Fadyl, J. K.; Payne, D.; Allan, R.; Kayes, N. That Says, For Me, You Are a Second-Class Citizen. *International Journal of Disability and Social Justice* **2025**, *5* (1). https://doi.org/10.13169/intljofdissocjus.5.1.0001
73. Nawaz, S.; Ali, R.; Batool, S.; Alaudeen, Z. Use of Internet among Youth and Its Effect on Library Attendance. *Pakistan Journal of Information Management & Libraries* **2015**, *16*, 29-37. https://doi.org/10.47657/201516748.
74. Adetayo, A. J. Are Physical Libraries Popular for Research in the Internet Age Post COVID-19? *Internet Reference Services Quarterly* **2022**, *26* (4), 231-245. https://doi.org/10.1080/10875301.2022.2090044.
75. Eom, S.-C.; Lee, S. Y. State of Study Spaces for Use of Intermediate Space in University Campus. **2022**, *31* (1), 55-62. https://doi.org/https://doi.org/10.14774/jkiid.2022.31.1.055.
76. Arroyo, R. A. Living Conditions and Academic Performance of Students Occupying Boarding Houses in Northern Mindanao. *CMU Journal of Science* **2023**. https://doi.org/10.52751/YRPZ9068.
77. Soltani, A.; Azmoodeh, M.; Doostvandi, M.; Sheikh Ahmadi, A.; Rahimi, M. Post-COVID-19 Campus Commuting Patterns and Influential Factors: Evidence from a Developing Country. **2024**. https://doi.org/10.1080/03081060.2023.2300800.
78. Burdick-Will, J.; Stein, M. Transit Trade-Offs: Public Transportation Difficulty, Schedule Variation, and School Preferences. **2025**.

https://doi.org/https://doi.org/10.1016/j.ssresearch.2025.103160.
79. Zhou, J. A Study on College Students Living off Campus by Renting. **2012**. https://doi.org/https://doi.org/10.3969/j.issn.1008-4002.2012.02.006.
80. Mafumbate, R.; Dlamini, S. M. Factors Leading to Choice of Staying Off-Campus by First Year Students in Eswatini Universities. **2021**.
81. Zasina, J.; Antczak, E. The 'Gown' Unconcerned with the Town? Residential Satisfaction of University Students Living in off-Campus Private Accommodation. *Housing Studies* **2021**. https://doi.org/https://doi.org/10.1080/02673037.2021.1961692.
82. Norton, E. C.; Dowd, B. E. Log Odds and the Interpretation of Logit Models. *Health Services Research* **2017**, *53* (2), 859–878. https://doi.org/https://doi.org/10.1111/1475-6773.12712.
83. Bella-Omunagbe, O.; Shakantu, W. The Influence of Satisfaction with Attributes of Off-Campus Student Accommodation on the Loyalty Behaviour of Student-Residents. **2014**. https://doi.org/https://doi.org/10.32738/CEPPM.201411.0026.
84. Nhlabathi, M. Dimensions of Students' Satisfaction with Residential Housing and Its Impact on Their Loyalty – A South African Study. **2021**. https://doi.org/https://doi.org/10.2478/remav-2021-0029.

Disclaimer/Publisher's Note: The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of CMUJS and/or the editor(s). CMUJS and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.

CMU Journal of Science
The Official Scientific Journal of Central Mindanao University
ISSN Print: 0116-7847 js.cmu.edu.ph ISSN Online: 2704-3703

Research Article

"*Vaklang TWAH*": Homosexuality in Honorio Bartolome de Dios' Select Short Stories

Von Daniel Romina Plasencia, DA

1 National University Philippines, vondanielplasencia@gmail.com

2 NU Cebu, Inc., vdrplasencia@nu-cebu.edu.ph

Citation: Plasencia, V. D. (2026). Vaklang Twah: Homosexuality in Honorio Bartolome de Dios' Select Short Stories. CMU Journal of Science, 30(1), 40

Academic Editor: Dr. Richard M. Rillo

Received: July 08, 2025
Revised: June 16, 2026
Accepted: June 16, 2026
Published: July 2, 2026

Copyright: © 2024 by the authors. Submitted for possible open access publication under the terms and conditions of the Creative Commons Attribution (CC BY) license (https://creativecommons.org/licenses/by/4.0/)

A B S T R A C T.

This study contributes to the evolving understanding of homosexuality, shedding light to sociocultural and socioeconomic influences at play in the Philippines. To represent a literary perspective, three short stories were selected from Honorio Bartolome de Dios' book "*Sa Labas ng Parlor*", namely: *Atseng*, *Kas*, and *Nobena*. The qualitative discourse analyses on the theme, context, and characterization provide deeper insight on the queered realities of the Filipino gay, or exaggeratedly expressed as *vakla* (commonly *bakla*). Judith Butler's *gender performativity* critiques how Filipinos depend on rigid heteronormative expressions to conform to the country's expectations shaped by complex and dissonant remnants of Western and Eastern cultural amalgamation. Additionally, the homosexual experience presents an *intersectional* degree of discrimination and stigma—as Kimberle Crenshaw explains it—in which sociocultural and socioeconomic facets of Filipino life confer a significant impact. Further, these factors purport Eve Sedgwick's concept of the *closet* where queer individuals struggle with cognitive dissonance in their identity and expression. Honorio Bartolome de Dios has a unique, yet largely relevant, method of storytelling Filipinos in their process of and acceptance of becoming; thus, the "*Vaklang TWAH*" model based on de Dios' textual portrayal of homosexuality is outlined.

Keywords: Filipino gay, homosexuality, Honorio Bartolome de Dios, Sa Labas ng Parlor, Vaklang TWAH model

INTRODUCTION

For decades, homosexuality has existed yet is perceived differently across cultures. It has evolved from being taboo and unlawful to being accepted and legal ever since the LGBTQ+ movement has risen in recent years (Kent & Poushter, 2020); and yet, many societies still uphold prejudices for homosexuality based on their culture, religion, or politics (Human Rights Watch, 2018).

At present, literature and media have had significant roles in the introduction of homosexuality with Western movies and novels depicting this universal human phenomena (Morris, 2023). Majority still perpetuate stereotypes or reduce these identities to cliche tropes (Dalton, 2016).

In the Philippines, homosexuality is complicated as Filipinos are shaped by its Catholic roots, Western influence, and native traditions that once embraced gender fluidity (Ildefonso, 2023). Nevertheless, Filipinos embrace homosexuality through its popular media figures despite the persistence of discrimination (De Guzman, 2022). Moreover, Philippine media portrays gay characters as comic relief or tragic figures defined by their sexuality (Mata, 2023).

Meanwhile, Philippine literature explores deeper, though such works remain underrepresented in the country. This shows the need for Filipino authors to write themes of homosexuality in Filipino culture. Honorio Bartolome de Dios' short stories provide a compelling lens to dive into these tensions as his works often probe these identities in Filipino societies.

In addition to this, analyzing de Dios' depictions of the Filipino gay, or hyperbolically *vakla* (or simply *bakla*), is important in understanding how Philippine literature contributes or challenges stereotypes on sexual orientation and gender identities. The themes in his stories may mirror societal contradictions while the sociohistorical context could reveal shifts in the perception towards homosexuality. Additionally, characterization may either subvert stereotypes or expose lingering biases. This analysis of de Dios' works may amplify marginalized voices in a nation where LGBTQ+ rights remain contested.

Furthermore, by utilizing global and local frameworks in the analysis of de Dios' works, this study bridges the gap between the LGBTQ+ experiences outside and inside the country. Finally, it contributes to the Sustainable Development Goal 5: *Gender Equality*.

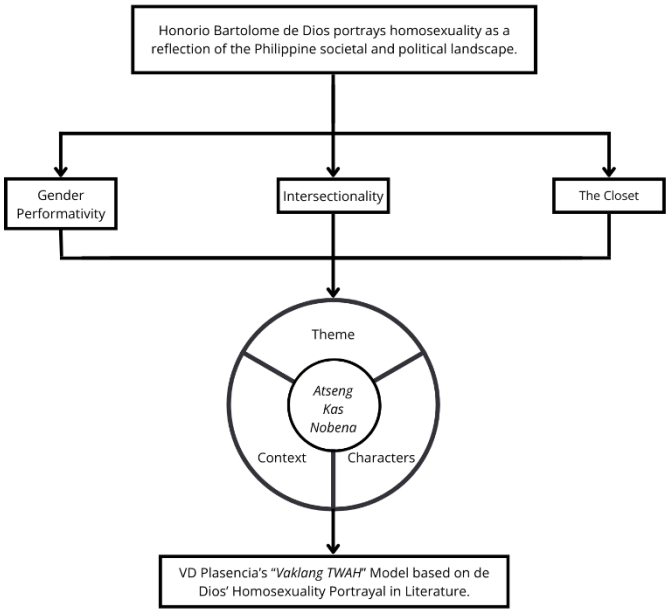


Figure 1. Schematic Diagram of the Study.

To aid in the analysis of the select short stories, the following lenses were used: *gender performativity*, *intersectionality*, and *the closet*.

In the late 1980s and early 1990s, scholars such as Judith Butler, Eve Kosofsky Sedgwick, and Teresa de Lauretis developed Queer Theory—a field of the study of gender and sexuality (Miller, n.d.). De Lauretis was often credited with inventing the term, however, Butler's "*Gender Trouble*" became the foundation and introduced concepts like *gender performativity*—which posits that identity is not innate but enacted through repeated behaviors and language which destabilizes rigid binaries like heterosexual/homosexual.

Developed by Kimberle Crenshaw, *intersectionality* emphasizes how overlapping systems of oppression—such as race, class, and gender—contribute to marginalized experiences (Coaston, 2019). Applying this to Philippine contexts, the portrayal of gayness in de Dios' works can be analyzed through intersections of religion, colonialism, and poverty which shows how these forces amalgamate discrimination or complicate queer liberation in Filipino narratives.

The metaphor of the *closet*—from Eve Sedgwick's queer critique—symbolizes the tension between secrecy and disclosure in queer lives (Orrells, 2023). In de Dios' stories, characters struggling with hidden desires or societal shame may embody the psychological and social costs of the *closet*. This framework presents how Filipino cultural values—like familial piety or Catholic morality—enforce silence around homosexuality which positions

the *closet* as both a site of repression and potential resistance.

To supplement the concepts used, the following related literature and studies were reviewed.

Dennis Altman's "*Global Sex*" (2001) goes over how globalization reshaped sexual identities and argues that Western LGBTQ+ discourses often clash with local traditions which creates multiple queer experiences. Altman's analysis emphasizes the tension between universal human rights frameworks and culturally specific expressions of queerness—a dynamic mirrored in literature where gay characters negotiate identity amid globalized and traditional norms.

Garcia's book, "Philipp*ine Gay Culture: Binabae to Bakla, Silahis to MSM*" (2008), provides a comprehensive analysis of Philippine gay culture by tracing the historical and discursive development of male homosexuality and the *bakla* identity from the 1960s to the present. The study examines how colonial history introduced the Western homo/hetero binary which further marginalized the effeminate *bakla* identity in the Philippines. By exploring various literary and artistic works created by gay writers, Garcia presents themes of hybridity, appropriation, and postcolonial resistance that have shaped contemporary LGBTQ+ identities. His work contributes to the understanding of Philippine gay culture as a dynamic and evolving discussion that reflects both historical influences and modern struggles for visibility and acceptance.

Larry Gross's "*Up from Invisibility: Lesbians, Gay Men, and the Media in America*" (2001) dives on the evolving representation of gay men and lesbians in American media which presents both progress and persistent limitations. Gross argues that while the media has moved toward greater visibility, they often fail to capture the full complexity of gay identity, instead presenting sanitized or stereotypical portrayals. He goes over the significant events—such as the rise of The Advocate and the first televised lesbian kiss—to show how visibility does not always equate to genuine representation. His work presents the media's struggle to break free from heteronormative constraints which emphasizes the need for more nuanced and authentic portrayals of LGBTQ+ experiences.

A global study by Kent and Poushter (2020), "*Global divides on homosexuality persist*", surveyed 34 countries to analyze cultural and legal attitudes toward LGBTQ+ communities. Using quantitative methods, the study revealed stark regional disparities—with higher acceptance in Western nations and pervasive stigmatization in regions with strong religious or traditional norms. Notably, it presented how media and education systems in progressive societies correlate with increased visibility and tolerance. This study put in context the tension between universal LGBTQ+ advocacy and localized resistance which frames de Dios' narratives within a broader global discourse where Filipino cultural norms—shaped by colonialism and religion—may similarly conflict with modern queer identities.

The study by Bautista et al. (2021), "*Religion and social tolerance: Generation Z's views on exposure to homosexuality in the mass media*", delves into the relationship between media exposure and social tolerance toward homosexuality among Generation Z in Isulan, Sultan Kudarat. The researchers present the media's role in creating attitudes—particularly among young individuals still forming their identities. They discuss how homosexuality has historically been misrepresented in mass media by often reinforcing stereotypes. By examining Generation Z's perceptions, the study reveals that media exposure does not significantly influence their views which led to a neutral stance on fully tolerating homosexuality in the community.

In "*Queer representation in Honorio Bartolome De Dios' Geyluv*", Valenzuela (2024) looks into the portrayal of queer identities and relationships in Filipino literature through a qualitative textual analysis of Geyluv. The study goes over how the story's main characters navigate internal and external conflicts which includes societal stigma, gender stereotypes, and issues of masculinity. By emphasizing the complicatedness of queer relationships, the research presents the influence of LGBTQ+ literature on readers' perceptions which fosters greater awareness and acceptance. Valenzuela stresses the importance of authentic representation in literature to challenge heteronormative views and advocate for a more comprehensive understanding of queer experiences in Filipino culture.

METHODOLOGY

This study employed a Qualitative Discourse analysis to look into the depiction of homosexuality in Honorio Bartolome de Dios' short stories found in his book "*Sa Labas ng Parlor*". This book was first published in 1998 by the University of the Philippines Press. Through Simple Random sampling, the following short

stories were identified and used as the source of data: *Atseng*, *Kas*, and *Nobena*. The choice of said sampling method entailed the investigation of patterns evident in de Dios' writing style and textual portrayal of homosexuality. Among the literary elements, this study focused on exploring the theme, context, and characterization of each story for a clearer grasp of its main objective.

RESULTS AND DISCUSSION

This section presents the findings and its corresponding discussion, which then served as reference for the de Dios-based literary model in portraying homosexuality.

Table 1. Thematic Analysis

Short Stories	Theme
Atseng	Queer Identity and Cultural Struggles in Rural Philippine Context
Kas	Queer Identity, Memory, and the Burden of the Past
Nobena	Queer Identity, Social Expectations, and the Burden of Tradition

The short story *Atseng* thematizes masculinity and *gender performativity*, specifically how young boys navigate the expectations of manhood in society. Butler's (1990) theory of *gender performativity* argues that gender is not an inherent identity but rather is enacted through repeated behaviors and social norms. This can be seen in the manner in which Ato and his friends participate in hyper-masculine acts like playing outside the fields and boasting about physical characteristics, reinforcing the rigid expectations of manhood. Their talk regarding Dodong's girlfriends and the crude discussions about women at the cinema portrayed in the line "*E, di alam mo kung ano'ng palabas sa sine sa Concepcion… S'yempre, bomba*," bring out how gender identity is constructed socially through discourse. These performative acts not only construct their masculinity but also reiterate the queerness marginalization, as evidenced in their mocking discussion about Atseng's life and tragic fate. Garcia (2008) adds that Philippine gay culture has been shaped by colonial history for a long time, where the effeminate *bakla* identity has been placed to being inferior to the heterosexual masculine ideal. The boys' labeling of Atseng as *malas* and inability to see beyond their sexuality reflect to this deeply rooted bias, reinforcing performative masculinity as a mechanism of self-survival within a stigmatizing society.

Moreover, the narrative also illustrates how *gender performativity* is manifested through the oppressive policing of queer identities and translates into violence as well as internalized repression. Ato's encounter with his cousin Dodong quietly highlights the blurred boundaries between acquired masculinity and coercion, as Dodong imposes a male sexual dominance expectation on him. Gross (2001) writes about how media portrayals tend not to represent LGBTQ+ lives in any meaningful way but rather reinforcing stereotypes of queer identities as hypersexualized or deviant. The story mirrors the ridicule of queerness as seen through boys making fun of Atseng and forceful imposition depicted in Dodong taking advantage of the vulnerability of Ato. And in its wider study across the world, Kent and Poushter (2020) also contextualize this struggle as part of a larger societal acceptability issue with most cultures still heavily influenced by religious and colonial remnants of stigma towards queerness. Ato's inner conflict—his silence, terror, and eventual participation in Dodong's coercion—reflects the debilitating effects of such rigid frameworks. His reluctance to engage in the phallic competition "*Kinabahan si Ato. Naalala niya ang naganap kahapon ng umaga*," further exemplifies of the way that masculinity is not merely performed, but aggressively enforced, leaving very little room for error. In this way, the narrative presents masculinity as a limiting, sometimes toxic act, mirroring Butler's statement that gender is a script imposed upon people as opposed to being an inherent reality.

The short story *Kas* delves into the complexities of identity and self-acceptance in a strictly defined sociocultural environment, reflecting Judith Butler's (1990) concept of *gender performativity*. The protagonist's struggle with self-recognition mirrors Butler's assertion that gender and identity are performed rather than inherent, influenced by societal expectations and repeated behaviors. In the story, the protagonist's reluctance—"*Mararahang katok ang kanina ko pa naririnig. Mga katok na wari'y pag-aalinlangan*"—reflects not just an external act of waiting but an internal tension regarding his own identity. His fixation on the appearance of his apartment, the way he makes sure his reflection stays clear in the mirror, symbolizes a deeper preoccupation with the self he shows to the world. As Garcia (2008) argues in "*Philippine Gay Culture*" the *bakla* identity has already been marginalized due to Western colonial influences, further complicating the protagonist's internal conflict. The story subtly highlights how performativity functions as both a shield and a burden, compelling the protagonist to navigate between his true self and societal expectations.

The protagonist's openness to Tony afterwards—his first genuine listener—further reveals performativity's role in identity formation. His confession, "*Tony, nakakasawa din pala ang patuloy na pagtatago. Pakiramdam ko minsan, ako mismo, hindi ko na kilala ang sarili ko,*" summarizes the exhaustion of having to uphold an invented self. Altman (2001) discusses how globalized sexual identities often clash with local cultures, and this tension is evident in the protagonist's journey. He recognizes the pressure to conform, yet his increasing awareness of his own agency in making his own narrative aligns with the findings of Valenzuela (2024), who emphasizes the role of literature in promoting greater acceptance of LGBTQ+ identities. The story's themes resonate with the broader debate on queer representation, as analyzed by Gross (2001), who critiques the media's sanitized portrayals of LGBTQ+ individuals. Here, literature serves as a counterpoint, offering a nuanced depiction of the protagonist's struggle and eventual self-acceptance. In the end, the story challenges rigid binaries by illustrating that identity is not static but continuously negotiated through personal and social interactions.

Nobena revolves around the conflict between traditional family roles and personal identity, specifically in terms of gender and sexuality. This theme corresponds to Judith Butler's (1990) theory of *gender performativity*. The protagonist, Jun, challenges the rigid expectations of masculinity imposed by his father, who sees homosexuality as a deviation from the normative trajectory of manhood. This struggle is evident in lines such as, "*Pareho kaming bakla ni Butch, kung 'yun ang ibig mong sabihin,*" which assert Jun's resistance to societal and familial pressures. Jun's father, deeply entrenched in heteronormative beliefs, reacts violently, mirroring what Dennis Altman (2001) describes as the tension between global queer identities and local traditional frameworks. Jun's refusal to conform to his father's expectations illustrates how gender and sexuality are performative acts that do not necessarily coincide with conventional standards imposed by patriarchal and religious orthodoxy.

In addition, the narrative demonstrates the performativity of masculinity and power dynamics within a family setting. Jun's father embodies the stereotypical patriarchal figure who insists on strict gender roles, expecting his son to exhibit traditionally masculine traits. This is evident in his outburst: "*Hoy Jun, tigas-tigasan mo nga ang kilos mo. Para kang babae kung kumilos!*" This policing of gender expression aligns with the analysis of Philippine gay identity by Garcia (2008), who highlights how the effeminate *bakla* identity has historically been marginalized due to colonial and Western binary constructs. The father's inability to accept Jun's sexuality emphasizes the generational and ideological gap presented in studies such as Kent and Poushter (2020), where one sees diverse attitudes towards LGBTQ+ identities from culture to generation. Jun's claim of his truth—"*Pinili ko ang buhay na ito. Puwes, baguhin mo. Why should I? Wala akong nakikitang dahilan*"—shows the strength of queer identities against erasure by society. His statements emphasize the importance of self-acceptance and refute the idea that one must perform heteronormativity in order to be legitimized as part of the family. This echoes the argument of Valenzuela's (2024) on how the LGBTQ+ literature produces increased awareness and changes the worldview by presenting the internal and external conflicts faced by queer individuals in Filipino society.

Table 2. Contextual Analysis

Short Stories	Context
Atseng	Colonialism, Religion, Masculinity, Queer Marginalization, Patriarchy, Socioeconomic Status

Kas	Colonialism, Religion, Masculinity, Oppression, Identity Crisis, Social Stigma, Resistance, Queerness
Nobena	Colonial Influence, Religion, Family Expectations, Gender Identity, Social Stigma, Heteronormativity, Masculinity, Queer Resistance

The short story *Atseng* depicts rural Filipino sociocultural realities, marrying poverty, masculinity, and queerness as identities marginalized from social expectations. There is *intersectionality* present in the experience of Ato as a young boy forced to contend with societal demands on masculinity and presented with both tacit and open assumptions about queerness. Drawing from Crenshaw's (1989) theory, the interaction of religion, colonial history, and socioeconomic limitations plays a role in stigmatizing non-conforming identities. The story shows how queerness, in the form of Atseng, is demonized, with characters linking him Bato bad luck: "*Basta sabi ni Ama, malas ang bakla*." This line captures how deeply rooted religious dogma entrenches discrimination, supporting Garcia's (2008) contention that the *bakla* identity has long been framed as an aberration under the Western homo/hetero binary imposed during colonial times. In addition, the narrative supports Dennis Altman's (2001) assertion that Western LGBTQ+ discourses tend to conflict with local customs, producing a fractured and conflicted queer identity in the Philippines.

Ato's experiences also highlight the power dynamics within patriarchal structures, as seen in his relationship with his cousin Dodong. The implicit coercion in their interaction—"*Tinitigasan ka na ba? 'Lika rito*"—demonstrates how masculinity is both policed and weaponized. This aligns with Valenzuela's (2024) discussion of queer representation in *Geyluv*, where societal stigma enforces rigid gender roles, pushing young boys into heteronormative expectations. Ato's silence during times of abuse is a representation of the internalized fear and helplessness *intersectionality* creates—his youth, class, and gender all locating him in a vulnerable position where he cannot fight back. The tension in the story mirrors Kent and Poushter's (2020) study, which emphasizes how cultural perceptions of homosexuality differ globally, with the Philippines struggling with religious conservatism and growing modern influences. The portrayal of Atseng's tragic fate—his murder—further cements the dangers of queer existence within a community that upholds rigid gender binaries. Thus, the short story serves as a microcosm of the overall struggles of queer Filipinos who exist at the intersection of colonial histories, religious conservatism, and patriarchal violence.

The short story *Kas* traces the sociocultural meaning of *intersectionality* by through how the protagonist navigates multiple layers of identity—queerness, masculinity, and sociopolitical activism. The conflict of the protagonist in embracing his sexual identity is shaped by colonial influences and religious norms, reflecting Garcia's (2008) assertion that Philippine gay culture is strongly influenced by Western binaries and local traditions. The presence of the Virgin Mary and crucifix in the protagonist's home is symbolic of the influence of Catholicism, solidifying the fact that religion dictates moral perceptions of queerness, creating an internal conflict for the protagonist. Crenshaw's (2019) *intersectionality* theory applies here as the protagonist experiences compounded marginalization—not only as a gay man but also as someone struggling with the pressures of heteronormativity. His hesitation to accept his identity is consistent with the research of Bautista et al. (2021), who argue that exposure to queerness in media does not always translate to acceptance, especially in deeply religious communities. The protagonist's reluctance is evident when he says, "*Pakiramdam ko minsan, ako mismo, hindi ko na kilala ang sarili ko.*" This line captures his internalized conflict and the societal forces that hinder his full self-acceptance.

Furthermore, the story critiques rigid masculinity through Tony's character, who represents political opposition but simultaneously embodies the expectations of traditional male roles. Dennis Altman's (2001) argument that globalization complicates local queer narratives is evident as the protagonist wrestles between Western notions of LGBTQ+ rights and the deeply embedded cultural stigmatization of effeminacy. His political and personal dilemmas intersect, affirming how sexual identity and activism are intertwined. Tony, despite his radicalism, also represents a heteronormative structure that challenges but does not fully validate the protagonist's queerness. The protagonist's line, "To*ny, nakakasawa din pala ang patuloy na pagtatago,*" signifies a moment of self-awareness, illustrating how he yearns for liberation beyond societal constraints. Valenzuela (2024) asserts that queer representation in Filipino literature promotes visibility and acceptance, yet the protagonist's journey reveals that genuine acceptance is still a long way to go. The story ultimately portrays *intersectionality* as a site of both struggle and potential resistance, emphasizing the need for nuanced representations of queer identities in Philippine literature.

Meanwhile, *Nobena* encapsulates the sociocultural conflicts of the protagonist, Jun, through showcasing the intersection of religion, colonialism, and family expectations in shaping his queer identity. Rooted in Kimberle Crenshaw's concept of *intersectionality*, Jun's experiences as a gay man in a conservative Filipino society highlight the overlapping oppressions he faces. His father's reaction to his sexuality—"*Putang-ina mo!*"—reflects the rigid heteronormativity imposed by patriarchal structures, further enhanced by colonial heritage that introduced the homo/hetero binary (Garcia, 2008). The church setting heightens the tension, emphasizing religion's role in reinforcing gender norms. "*Malungkot ang mukha ng Ina sa altar*" symbolically represents divine judgment and societal rejection. This aligns with Bautista et al. (2021), who found that religious institutions play a major role in influencing societal attitudes towards homosexuality. The insistence of the father that Jun adhere to traditional masculinity—"*Hoy Jun, tigas-tigasan mo nga ang kilos mo*"—also shows how gender performance dictates acceptance, a conflict exacerbated by machismo during the colonial period and male dominance expectations.

Furthermore, Jun's queerness exists in a liminal space, shaped by both Western LGBTQ+ discourse and localized Filipino traditions. Dennis Altman's (2001) argument that globalization complicates queer identity is evident in Jun's defiance against imposed norms: "*Masaya ako sa ganito*". His assertion of agency challenges the notion that queerness is merely a Western import, instead affirming its existence within indigenous and contemporary Filipino identities. The father's dismissal of Jun's love for Butch as *kagaguhan* (stupidity) reflects the societal delegitimization of same-sex relationships, a phenomenon also explored in Valenzuela's (2024) study on queer representation in Geyluv. However, Jun's resistance against patriarchal and religious condemnation signifies a broader push toward visibility and self-acceptance, despite systemic barriers. As Kent and Poushter (2020) suggest, cultural and religious attitudes deeply influence queer acceptance, making Jun's narrative emblematic of a broader Filipino LGBTQ+ struggle. Thus, the story not only portrays personal conflict but also critiques the sociocultural forces that perpetuate exclusion, emphasizing the ongoing negotiation between identity, family, and faith.

Table 3. Characterization Analysis

Short Stories	Character	Representation
Atseng	Ato	Burdened by Shame and the Struggle for Identity
	Dodong	Defiance and the Fight for Queer Freedom
	Atseng	The Haunting Presence of Cultural and Religious Oppression
Kas	Rod	Caught Between Manhood and Self-Discovery
	Tony	The Outsider Navigating Queer Complexity
Nobena	Jun	Hidden Truths and the Fear of Exposure
	Jun's Father	Patriarchal Authority and Rigid Masculinity

In *Atseng*, Ato is the representation of the conflict between innocence and an emerging awareness of his own sexuality. His reactions, especially his discomfort and confusion, reflect the psychological cost of the *closet* as theorized by Sedgwick (Orrells, 2023). The *closet* metaphor manifests in his silent observations—his hesitation in confronting his desires and fears, especially in the presence of his cousin, Dodong. Ato's silence when questioned about arousal—"*Tinitigasan ka na ba?*"—mirrors the forced repression dictated by societal and familial expectations. His avoidance and internal turmoil highlight how young individuals are conditioned to suppress or remain unaware of their sexuality due to cultural taboos and religious morality (Garcia, 2008). The scene where he hesitates to urinate, fearing the reaction of his peers, represents how masculinity is both performed and policed, forcing boys like Ato into roles they may not fully understand or accept.

Dodong represents a predatory force shaped by both repressed desires and societal neglect. His character is deeply entwined with the *closet* metaphor, portraying the dangers of unresolved, hidden desires that manifest in harmful ways. Dodong's exploitation of Ato echoes the structural issues in Philippine LGBTQ+ narratives where queer experiences, particularly those deviating from heteronormativity, are either demonized or silenced (Valenzuela, 2024). The secretive and coercive nature of their interaction suggests the way patriarchal structures enforce silence, reflecting the global queer experiences discussed by Altman (2001). The collective mockery of Atseng's identity highlights the danger of societal

rejection, ultimately leading to their tragic fate. In a community where queer individuals like Atseng are seen as burdens or bad omens, the cycle of repression and violence within the *closet* continues, reinforcing Garcia's (2008) argument on postcolonial LGBTQ+ identity struggles. The metaphor of the storm throughout the story mirrors the tension—Ato, like the brewing storm, is on the verge of realizing his place in a world that refuses to acknowledge his unspoken truths.

In *Kas*, Rod's character is an exploration of the metaphorical *closet*—an enclosed space of secrecy and restraint. His hesitation in answering the door, his meticulous arrangement of his apartment, and his internal monologue all symbolize his attempt to maintain control over his carefully curated identity. As Eve Sedgwick (1990) posits, the closet is not just about secrecy but also about performance, and Rod's meticulous environment mirrors this performativity. The passage where he reflects on the well-maintained mirror—"*ang salamin na palagi kong nililinis upang manatiling malinaw ang repleksiyon ng sino mang haharap dito*"—serves as a metaphor for his struggle with self-perception and the societal gaze. His reluctance to fully embrace his queerness is further reinforced by the expectations set by Filipino familial and religious values, as discussed in Garcia's (2008) examination of Philippine gay culture. Rod's hesitance to fully engage with Tony and his radical ideals suggests his internalized fear of breaking free from the societal mold, reinforcing the notion that the *closet* is both a site of repression and a place of self-preservation.

In contrast, Tony embodies the queer other—his queerness is inseparable from his activism. He challenges not only heteronormative structures but also political oppression, as seen in his involvement in student protests. His character aligns with Altman's (2001) discussion on how globalization and activism influence queer identities, particularly in societies where traditional values and modern ideologies clash. The line, "*Tinanggihan ko siya. Hindi ako handa at hindi ko alam kung kailan ako magiging handa,*" highlights the contrast between Tony's openness and Rod's reluctance. Tony's willingness to embrace his identity and ideology forces Rod to confront his own insecurities, as reflected in his eventual admission: "*Tony, nakakasawa din pala ang patuloy na pagtatago.*" Here, Tony acts as both a catalyst and a mirror, exposing Rod's internal conflict and offering him a glimpse of a life unrestrained by the *closet*. Through these characters, de Dios' narrative exemplifies the tension between repression and liberation, a struggle that remains central to queer representation in Philippine literature.

Meanwhile, in *Nobena*, Jun embodies the struggles of queer identity within a deeply conservative and patriarchal Filipino society. His journey is shaped by the *closet* metaphor, a space of both repression and self-awareness. His dialogue with his father reveals the tension between personal truth and societal expectations: "*Now, will you please get straight to the point. Alam rin ba niya ang relasyon ko kay Butch?*" This confrontation highlights Jun's courage in coming out, despite the looming presence of judgment. The concept of the *closet*, as discussed by Sedgwick (Orrells, 2023), reflects the oscillation between concealment and revelation—Jun, after years of silence, chooses disclosure as an act of defiance and liberation. His father's reaction—filled with expletives and demands for conformity—mirrors the cultural expectation that masculinity equates to heterosexuality. This aligns with Garcia's (2008) analysis of how colonial history introduced rigid gender binaries that marginalized *bakla* identities, reinforcing the idea that queerness must be hidden to preserve familial honor.

Conversely, Jun's father embodies patriarchal authority and the rigid enforcement of heteronormativity. His anger upon discovering Jun's sexuality—"*Totoo palang nakikipagbaklaan ka sa pamangkin ni Lope. Putang-ina mo!*"—demonstrates the violent rejection of queerness within traditional Filipino households. His character epitomizes the generational divide in perspectives on sexuality, where fathers enforce silence and compliance, much like the institutional forces described in Kent and Poushter's (2020) study on global attitudes toward homosexuality. His inability to accept Jun's identity also echoes Altman's (2001) argument that globalization clashes with local traditions, creating fractured experiences for LGBTQ+ individuals. Despite his outward dominance, Jun's father is also trapped—by cultural expectations, by his own failures, and by the burden of maintaining a rigid sense of masculinity. His demand for Jun to change—"*Tigilan mong kagaguhang 'yan*"—represents the suffocating weight of the *closet*, wherein those outside its confines attempt to force others back into its darkness. However, Jun's refusal to conform highlights the potential for resistance within the *closet* metaphor, positioning queer identity as an act of defiance against oppressive cultural norms.

C O N C L U S I O N

This study deeply delved into the intertextual underpinnings of Honorio Bartolome de Dios' lens of the Filipino gay or *vakla* (*bakla*) via a nuanced investigation of the theme, context, and characterization of his select short stories, namely: *Atseng*, *Kas*, and *Nobena*. The findings expose the intricacies of Filipino culture and norms—which complicatedly is a result of generational cognitive dissonance between Western and Eastern influences—and what it means to be gay. The theme of each story presents similarity in terms of the struggle between gender identity and expression where gender is seemingly only performed in conformity to heteronormative expectations and demands. This is also affected by the sociocultural and socioeconomic contexts where the characters and their queerness are subjected to varying forms of discrimination and stigma. Finally, these only widen and complicate the design of each character's *closet*, furthering them into deeper cognitive dissonance between their self-acceptance, self-expression, and self-awareness. It can be concluded that Honorio Bartolome de Dios was able to capture what it means to be homosexual in the Philippines in specific stages of life and social standing.

P A T E N T S (O U T P U T)

Upon concluding the results, the study proposes VD Plasencia's "*Vaklang TWAH*" model which introduces the intricate levels of homosexual storytelling established by de Dios in his book "*Sa Labas ng Parlor*".

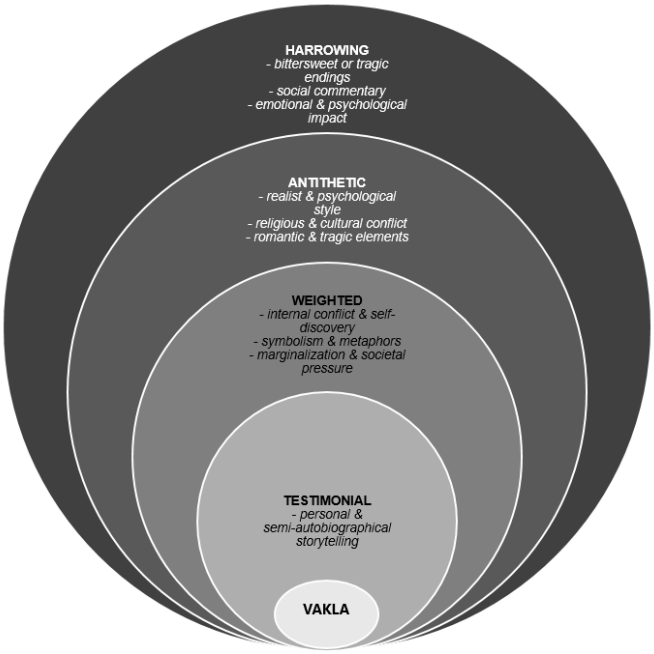


Figure 2. VD Plasencia's "Vaklang TWAH" model based on de Dios' Homosexuality Portrayal in Literature.

This model may be used as a guide describing the phenomenon of the Filipino gay or *vakla*. There are five layers in this spherical model where the *vakla* or simply *bakla* is at its core, setting their experience and perspective as the barometer for the literary elements to be used. From there, the remaining four layers—*testimonial*, *weighted*, *antithetic*, and *harrowing*—can be acronymed as *TWAH*, an exaggeration of the Filipino word "*ito*" (or *this* in English). This forms the gay expression "*vaklang twah*" (*baklang ito* or this gay) which particularizes a specific gay person.

The secondary layer, *testimonial*, introduces the identity of the *vakla* through personal and semi-autobiographical storytelling, establishing a ring of authenticity. De Dios' stories are frequently based on actual experiences, and they mirror his own observations and struggles. Through the use of both narrative and descriptive modes, queer identities are brought to life, enabling readers to walk in the shoes of characters before their struggle with their sexuality in a repressive society. For instance, prior to delving into Ato's (from *Atseng*) queer awakening, his socioeconomic life was described through the line "*Umaabon pa'y nasa gitna na sila ng bukid, namumulot ng kuhol. Idineklara sa radyong walang pasok sa eskuwela kaya hindi magkamayaw sa tuwa ang magkakalaro habang nagtatampisaw sa putika*." This fundamental style is the backbone of de Dios' literary strategy, turning his tales not only into fictional stories but also into emotional testaments of lived reality.

The tertiary layer, *weighted*, is expounded further via the use of intricate literary elements, emphasizing the burdens of internal struggle and self-discovery as the characters grapple with their sexuality and fight religious and societal repression. Symbolism and metaphors, like changing seasons, religious ceremonies, and limited spaces, reinforce these conflicts by symbolizing emotional states and social constraints. This layer is subtly portrayed in *Kas* by analogizing hetero-conformity with political activism, "*Minsan, nakikisigaw na rin ako. Baka kasi mapagkamalan akong ahente kung hindi man lang ako nagsasalita sa loob ng mga hanay.*" Marginalization and social pressure further heighten the characters' experiences, frequently resulting in discrimination, isolation, and rejection, highlighting the brutal realities of LGBTQ+ people.

The quarternary layer, *antithetic* (oppositions), employs a realist and psychological approach that probes raw emotions and inner conflict. De Dios usually highlights religious and cultural tensions, particularly the clash between Catholic guilt, traditional norms, and personal identity, such as how Jun responds to his dad in *Nobena* when told nothing will come from gay relationships by saying, "*Isinusulat pa lang ang Bibliya, 'yan na ang sinasabi nila. Obsolete statement na 'yan, Dad.*" De Dios also critiques patriarchal dominance, heteronormativity, and systemic discrimination, exposing how these forces shape and constrain queer experiences. Much of his work revolves around romantic yet tragic love stories, where love is either unrequited or leads to heartbreak. These motifs emphasize the agonizing sacrifices queer individuals must endure—whether by conforming to societal expectations, facing familial rejection, or resisting oppressive structures that deny them their truth.

Finally, in the outer layer, *harrowing*, the narrative outcomes tend to end in bittersweet or tragic ways, where characters silence their identity or reap the aftermath of exposing it. Through social commentary, the tales provide insight into the oppression and hardships of queer people in a conservative world. In the end, de Dios' writings make an enduring emotional and psychological impact, encouraging empathy and self-reflection among readers. Showing the gritty, painful, and very human struggles of the LGBTQ+ population makes his writing a powerful tool in campaigning for representation and comprehension.

It is important to note that the "*Vaklang TWAH*" model serves to shed light unto the concept of the queer spectrum, showing that there is more than one way to be a Filipino gay. One story does not represent the entire vakla experience, but rather only a speck of an entire collective phenomenon.

Author Contributions: This research is conducted by a sole author.

Funding: This research received no external funding.

Data Availability Statement: The primary data for this research is the book "*Sa Labas ng Parlor*" by Honorio Bartolome de Dios, which can be purchased at the UP Press bookstore.

Acknowledgments: The author extends their acknowledgement to the inspiration behind the study, the novel's author and the movie's cast. Further, a warm gratitude to the author's Literature professor, Dr. Lito Diones of Cebu Normal University, for their moral support and guidance on the study's direction.

Conflicts of Interest: The author declares no conflicts of interest.

REFERENCES

1. Altman, D. (2001). *Global sex*. Retrieved from https://press.uchicago.edu/ucp/books/book/chicago/G/bo3630562.html
2. Bautista, S., Bennagen, N., Espino, Q., & Tabanao, K. (2021). *Religion and social tolerance: Generation Z's views on exposure to homosexuality in the mass media*. Retrieved from https://ejournal.upi.edu/index.php/religio/article/view/41432.
3. Coaston, J. (2019). *The intersectionality wars. Vox*. Retrieved from https://www.vox.com/the-highlight/2019/5/20/18542843/intersectionality-conservatism-law-race-gender-discrimination.
4. Dalton, D. (2016). *The criminalization of homosexuality in popular cinema*. Retrieved from https://doi.org/10.1093/acrefore/9780190264079.013.102.
5. De Guzman, C. (2022). *In the Philippines, you can be both openly LGBT and proudly Catholic. But it's not easy*. Time. Retrieved from https://time.com/6184345/lgbt-philippines-catholic-church-pride.
6. Garcia, J. (2008). *Philippine gay culture: Binabae to bakla, silahis to MSM*. Retrieved from https://press.uchicago.edu/ucp/books/book/distributed/P/bo37851480.html.
7. Gross, L. (2001). *Up from invisibility*. Retrieved from https://cup.columbia.edu/book/up-from-invisibility/9780231119535.
8. Human Rights Watch. (2018). "*All we want is equality.*" Retrieved from https://www.hrw.org/report/2018/02/19/all-we-want-equality/religious-exemptions-and-discrimination-against-lgbt-people.
9. Ildefonso, T. (2023). *From Asog to Bakla: Genealogical analysis of the Philippine history to diagnose the roots of homophobia*. Retrieved from https://doras.dcu.ie/28009/2/Ildefonso%20Humanities%20Bulletin%205.2.pdf.
10. Kent, N. & Poushter, J. (2020). *The global divide on homosexuality persists*. Pew Research Center. Retrieved from https://www.pewresearch.org/global/2020/06/25/global-divide-on-homosexuality-persists.
11. Mata, A. (2023). *Keeping and challenging familial attachments: The bakla within contemporary*

mainstream Filipino film. Retrieved from https://repository.usfca.edu/honors/62.
12. Miller, J. (n.d.). *Chapter 2: Thirty years of queer theory*. Retrieved from https://courses.lumenlearning.com/suny-lgbtq-studies/chapter/introduction.
13. Morris, B. (2023). *A brief history of lesbian, gay, bisexual, and transgender social movements*. Retrieved from https://www.apa.org/topics/lgbtq/history.
14. Orrells, D. (2023). *Socrates and Sedgwick: Ancient Greece in Epistemology of the Closet*. Retrieved from https://www.taylorfrancis.com/chapters/edit/10.4324/9781003184584-31/socrates-sedgwick-daniel-orrells
15. Valenzuela, C. (2024). *Queer representaiton in Honorio Bartolome de Dios' Geyluv*. International Journal of Integrative Sciences. Retrieved from https://www.researchgate.net/profile/Christian-Loid-Valenzuela/publication/381854454_Queer_Representation_in_Honorio_Bartolome_De_Dios'_Geyluv/links/6682813ef3b61c4e2ca0f6e1/Queer-Representation-in-Honorio-Bartolome-De-Dios-Geyluv.pdf.

Disclaimer/Publisher's Note: The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of CMUJS and/or the editor(s). CMUJS and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.

CMU Journal of Science
The Official Scientific Journal of Central Mindanao University
ISSN Print: 0116-7847 js.cmu.edu.ph ISSN Online: 2704-3703

Research Article

Utilizing Strong-Alkalized Cocoa Bean Shell Powder as a Functional Cocoa Substitute in Chocolate Cupcakes

Eliezer Jr. P. Valencia[1], Argel A. Largado[1], John Joseph C. Menia[1], Romel M. Felismino[1], Katherine Ann T. Castillo-Israel[1,2], and Sheba Mae M. Duque[1,2*]

[1]Institute of Food Science and Technology, College of Agriculture and Food Science, University of the Philippines Los Baños 4031 Laguna, Philippines; epvalencia@up.edu.ph (EJPV); aalargado@up.edu.ph (AAL); jcmenia@up.edu.ph (JJCM); rmfelismino@up.edu.ph (RMF); kcisrael@up.edu.ph (KATCI); smduque@up.edu.ph (SMMD)

[2]Natural Products Development Program, University of the Philippines Los Baños 4031 Laguna, Philippines; kcisrael@up.edu.ph (KATCI); smduque@up.edu.ph (SMMD)

*Correspondence: smduque@up.edu.ph

ABSTRACT.

Cocoa bean shell (CBS) is a major byproduct of cocoa processing which is typically discarded. This study explored the potential of strong-alkalized CBS powder (SA-CBS) as a sustainable, functional substitute for cocoa powder in chocolate cupcake formulations. Cupcakes were prepared with varying levels of SA-CBS substitution (0, 25, 50, 75, 100%) and evaluated for physicochemical and sensory properties. Physical properties such as height, weight, diameter, texture, and color were measured, and consumer acceptability assessed through sensory evaluation. Proximate analysis was performed on the most preferred formulation to determine nutritional composition. Results showed that SA-CBS powder substitution had no significant effect on cupcake weight and lower diameter ($p<0.05$), but significantly influenced other properties, including upper diameter, height, specific volume, texture, and color. Consumer acceptability tests showed that the 50% SA-CBS formulation was most preferred, particularly for its dark appearance, moist texture, and chocolate flavor. Proximate analysis of this formulation revealed 39.5% moisture, 2.58% ash, 24.75% fat, 0.24% fiber, 20.65% protein, 250.55 mg/g total sugars, and 12.27% nitrogen-free extracts. These findings demonstrate that SA-CBS powder is a promising cocoa powder alternative in baked goods. Its favorable sensory attributes, along with high protein and fat content, highlight its functional, nutritional, and sustainable value for food applications.

Keywords: Cupcake Quality, Cocoa powder substitution, Strong-alkalized cocoa bean shell, Consumer acceptability test, Cocoa bean shell cupcakes

Citation: Valencia, E. J. ., Largado, A. ., Menia, J. J., Felismino, R., Castillo-Israel, K. A., & Duque, S. M. (2026). Utilizing Strong-Alkalized Cocoa Bean Shell Powder as a Functional Cocoa Substitute in Chocolate Cupcakes. CMU Journal of Science, 30(1), 51

Academic Editor:
Dr. Einstine M. Opiso

Received: July 14, 2025
Revised: June 18, 2026
Accepted: June 23, 2026
Published: July 2, 2026

Copyright: © 2024 by the authors. Submitted for possible open access publication under the terms and conditions of the Creative Commons Attribution (CC BY) license (https://creativecommons.org/licenses/by/4.0/).

INTRODUCTION

Cocoa (*Theobroma cacao* L.), a key Philippine agricultural product, is essential for chocolate production, yielding high-value products, including cocoa nibs, liquor, butter, powder, and confectionery blocks. Known for its antioxidant and vitamin content, cocoa thrives in the country's favorable climate, providing a competitive advantage in Asia [1]. However, the increasing demand for cocoa has also resulted in increased processing by-products, posing economic and environmental challenges. One major by-product, cocoa bean shells (CBS), is often discarded, although their high fiber and antioxidant content suggests potential for food industry applications [2]. Therefore, repurposing CBS can enhance sustainability by maximizing its nutritional potential and adding value to cocoa production.

Several studies have explored CBS as a food ingredient, including its use as an alternative to wheat flour [3], incorporation in cereal bars [4], and application as a source of dietary fiber [5]. However, CBS may contain mycotoxins, heavy metals, polycyclic aromatic hydrocarbons (PAHs), and microorganisms, which may pose health risks [6,5]. Despite its nutritional potential, the incorporation of CBS into food products remains limited due to undesirable sensory attributes, variable composition, and potential safety concerns. Thus, processing strategies that enhance its functionality and consumer acceptability are necessary to enable its wider application as a sustainable food ingredient. These risks can be mitigated through processing approaches such as alkalization, which may improve the safety and functional properties of CBS while preserving its beneficial compounds, making it more suitable for food product development.

In cocoa powder production, alkalization using sodium hydroxide or potassium carbonate enhances solubility, reduces acidity, and decreases bitterness and astringency [7]. This process elevates the pH of natural CBS powder from 6 to 8 [8], improving color and flavor through reactions between cocoa pigments and the alkalizing agent [9]. Alkalization can be categorized into light, medium, and strong levels, wherein stronger alkalization produces a deeper color and more pronounced flavor, making alkalized cocoa ingredients suitable for various dairy and bakery applications [9]. Previous studies have explored the potential of alkalized CBS as a food ingredient; however, its application in formulated bakery products remains limited. In particular, the incorporation of strongly alkalized CBS (SA-CBS) as a partial substitute for cocoa powder in chocolate cupcakes has not been extensively investigated. Since cocoa powder significantly contributes to the color, flavor, and overall acceptability of chocolate bakery products, evaluating the effects of SA-CBS incorporation is necessary to determine its feasibility as a sustainable cocoa-derived ingredient.

Given its fiber content and improved sensory characteristics after alkalization [7], CBS powder has potential as a cocoa powder substitute in baked goods. Chocolate cupcakes represent a suitable food system, specifically for high-moisture, leavened baked goods, for evaluating SA-CBS incorporation because cocoa powder contributes significantly to the color, texture, and sensory attributes of chocolate-based bakery products. Therefore, assessing the effects of SA-CBS substitution on physicochemical properties and consumer acceptability is essential in determining its potential as a sustainable cocoa-derived ingredient. Additionally, the utilization of CBS offers environmental and economic benefits due to the increasing generation of cocoa processing waste. Globally, an estimated 700,000 tons of cocoa bean shell (CBS) waste are generated annually [10,11], highlighting the need for sustainable valorization strategies.

Given the aforementioned research gaps, this study evaluates the potential of SA-CBS powder as a sustainable cocoa-derived ingredient in chocolate cupcakes formulated with varying levels of SA-CBS substitution, thereby addressing an important gap in the literature. The effects of SA-CBS incorporation on the physicochemical, physical, and sensory properties of the cupcakes were assessed to determine its feasibility as a cocoa powder substitute. By evaluating the influence of substitution level on product quality, this study is expected to provide insights into the development of sustainable cocoa-based ingredients and value-added applications for cocoa processing by-products. The findings from this study are expected to contribute to the growing body of research on food by-product valorization by providing practical insights into the application of CBS as a sustainable and functional ingredient in bakery products.

METHODOLOGY

2.1 Materials

The CBS were sourced from Malagos Agri-Ventures Corporation in Davao City, Philippines, collected after the winnowing process during chocolate production. The CBS was ground, vacuum-sealed in PE bags, and stored at -20 °C until use. Other chocolate cupcake ingredients, including all-purpose flour, wheat gluten, cocoa powder, sugar, baking

powder, modified starch, iodized salt, vegetable oil, vanilla extract, butter, eggs, and water, were purchased from a supermarket locally found in Los Baños, Laguna, Philippines.

2.2 Chemical Preparation

All solvents and reagents used were analytical grade.

2.3 Alkalization of Cocoa Bean Shell powder

The alkalization of CBS was carried out using NaOH as the alkalizing agent. Thirty grams of CBS powder was added to 150 mL of 2.53% NaOH (w/w) solution. The mixture was then stirred until a homogeneous slurry was formed. The slurry was then heated in a water bath (50 °C) for 30 minutes with constant stirring at 1150 rpm. Afterwards, it was dried in an oven dryer at 75 °C for 17 hours. The dried sample was ground, sieved through a 20-mesh sieve, and stored at -20 °C. The resulting SA-CBS powder had a pH of 7.64 ± 0.036, while the commercial cocoa powder had a pH of 8.02 ± 0.021. Both values fall within the optimal pH range for SA-CBS powder (7.6–8.2 or higher) [12]. In addition to its suitable pH, the SA-CBS powder contained 4.56% moisture, 12.72% ash, 7.43% fat, 8.71% fiber, and 19.68% protein, indicating its potential as a nutrient-rich ingredient.

2.4 Chocolate cupcake production

Chocolate cupcakes were prepared following the method of Souza et al. [3], with modifications. The chocolate cupcake formulations were based on a total flour basis of 56 g, composed of 28 g all-purpose flour and 28 g wheat gluten. All ingredients were expressed in baker's percentages relative to this flour basis. The fixed ingredients across all formulations included 71.43% sugar, 10.71% baking powder, 5.36% modified starch, 1.79% iodized salt, 32.14% vegetable oil, 10.71% vanilla extract, 25% butter, 71.43% egg, and 89.29% water. Commercial cocoa powder and SA-CBS powder were substituted at levels of 0%, 25%, 50%, 75%, and 100% of a total 14 g, corresponding to 25% of the flour basis. The substitutions were as follows: 0% SA-CBS (14 g cocoa powder), 25% SA-CBS (10.5 g cocoa powder, 3.5 g SA-CBS), 50% SA-CBS (7 g cocoa powder, 7 g SA-CBS), 75% SA-CBS (3.5 g cocoa powder, 10.5 g SA-CBS), and 100% SA-CBS (14 g SA-CBS). All dry ingredients were weighed using a digital scale (Reznor SF-400, Philippines), mixed thoroughly, and combined with wet ingredients using a wire whisk until homogeneous. The batter was poured into cupcake molds and baked at 180 °C for 10 minutes. Doneness was confirmed through internal temperature measurements (93–98 °C) and texture evaluations. Afterward, the cupcakes were cooled to room temperature prior to profile, color, sensory, and proximate analyses.

2.5 Chocolate cupcake properties

2.5.1 Physical profile of chocolate cupcakes

Cupcake diameter and height were measured using a digital caliper (Ingco, Philippines), while weight was determined using an analytical balance (OHAUS corporation, USA).

Volume was measured using the rice grain displacement method, based on AACC Method 10-05.01:1998 with minor modifications [13-16]. A container of known dimensions was initially filled with rice grains to determine its baseline volume. Each cupcake was then placed on a thin layer of rice at the bottom of the container, which was refilled with rice grains until level. The volume of displaced rice, corresponding to the cupcake volume, was measured using a graduated cylinder. Cupcake volume per unit weight was calculated using the formula:

$$\text{Volume per unit weight for cupcake} = \frac{\text{Volume of excess seeds (mL)}}{\text{Weight of the cupcake (g)}} \quad (1)$$

2.5.2 Texture profile analysis of cupcakes

The texture of each cupcake was analyzed using an EZ-SX texture analyzer (Shimadzu Corp., Japan), following Olaerts et al. [17]. After cooling at room temperature for 30 minutes, 25 mm-high and 30 mm-diameter crumb cylinders were extracted from the center and compressed twice to 30% of their original height at 100 mm/min using a 75 mm cylindrical probe, with a 3-second rest between compressions. Hardness was determined as the maximum peak force (N) from the force-time graph [18].

2.5.3 Color analysis of cupcakes

The color of each cupcake was analyzed using a chromameter (Konica Minolta, Japan), measuring L* (black to white), a* (greenness to redness), and b* (blueness to yellowness) values, following the methods described by Tinchan et al. [16] with minor modifications.

The color of each formulation was determined by comparing it to the other formulations to assess variations in color attributes. In this analysis, each formulation served as

both a sample and a reference point. The reference point in each calculation corresponded to the formulation against which another formulation's color attributes were compared. The color differences between samples were calculated using the equation:

$$\text{Color Difference: } \Delta E^*_{ab} = \sqrt{(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2}$$

$$= \sqrt{(L^*_1 - L^*_2)^2 + (a^*_1 - a^*_2)^2 + (b^*_1 - b^*_2)^2} \quad (2)$$

Where:

L* indicates lightness, a* represents the red-green axis, and b* denotes the yellow-blue axis. Values with subscript $_1$ represent components of the first sample, while values with subscript $_2$ correspond to the second sample.

For the total color difference between formulations, the following criteria were applied: $\Delta E^* < 1$, color differences are not evident to the naked human eye; $1 < \Delta E^* < 3$, color differences are not noticeable to the naked eye; and $\Delta E^* > 3$, differences are noticeable to the naked eye [19].

2.5.4 Sensory analysis of cupcakes

A consumer acceptability test was done to evaluate the sensory attributes of chocolate cupcakes and determine the most desirable formulation. Forty-five untrained panelists (aged 18 to 59 years old) assessed the appearance, texture, taste, and overall quality of the cupcakes using a 9-point hedonic scale.

2.6 Proximate analysis of the desired cupcake formulation

The most preferred chocolate cupcake formulation was analyzed for proximate composition to determine moisture, fat, fiber, ash, protein, and nitrogen-free extracts, following AOAC [20] with slight modifications. A nitrogen-to-protein conversion factor of 6.25 was used to calculate crude protein. The total sugar content was determined using the phenol sulfuric acid method from Tamboli et al. [21], with minor modifications.

2.7 Statistical Analysis

The study conducted all experiments and analyses in triplicate, and the results are reported as mean ± standard deviation. All statistical analyses were performed using a significance level of $p<0.05$. Data normality was checked using the Wilk-Shapiro test. One-way ANOVA was used to analyze normally distributed data (95% confidence level), followed by Tukey's test using Minitab® 21 (Minitab, LLC, USA) for post-hoc comparisons. Non-normally distributed data were analyzed using the Kruskal-Wallis test, with Dunn's test performed using IBM® SPSS® (IBM Corp., USA) for post-hoc analysis. Pearson's correlation tests were also conducted using IBM® SPSS® (IBM Corp., USA) to examine relationships between physical and sensory values, while a correlation heatmap was generated using R Studio 4.4.3 (Posit, PBC, USA).

RESULTS AND DISCUSSION

This study evaluated the potential of strong-alkalized cocoa bean shell (SA-CBS) powder as a food ingredient by formulating chocolate cupcakes with varying levels of SA-CBS substitution (0%, 25%, 50%, 75%, and 100%). The effects of SA-CBS incorporation on the cupcakes' physicochemical and sensory properties were assessed. Specifically, physical properties, color, texture profile, sensory acceptability, and proximate composition of the selected formulation were analyzed and evaluated. Figure 1 shows the formulated cupcakes, illustrating the differences in appearance among the various SA-CBS powder concentrations.

3.1 Physical Characteristics of Chocolate Cupcakes with SA-CBS powder

3.1.1 Physical Profile

The weight, height, upper and lower diameters, and specific volumes of the cupcakes in each formulation were measured to evaluate the effect of the SA-CBS powder on its physical and structural characteristics. The results are shown in Table 1. The weight of the cupcakes remained consistent across all substitution levels, indicating that the inclusion of SA-CBS powder did not significantly alter the total mass of the baked products. Both upper and lower diameters were generally comparable across treatments. However, a significant difference in upper diameter was observed between the 25% and 75% SA-CBS samples, with the 25% substitution yielding a smaller upper diameter. This may be attributed to the fibrous nature of SA-CBS powder, which can increase batter density by absorbing moisture, thereby limiting spread during baking and reducing the upper diameter [22]. Interestingly, the 25% substitution sample had a smaller upper diameter than the 75% sample, contrary to expectations based on fiber content. This deviation may be explained by external factors such as uneven oven temperature. Traditional ovens are prone to temperature fluctuations due to inconsistent heat circulation, leading to hot and cold spots that can influence expansion and moisture retention during baking [23,24].

Cupcake height was significantly reduced in the 100% SA-CBS sample compared to the control (0%

substitution), suggesting that full replacement impacts product rise. No significant height differences were observed among the intermediate substitution levels (25% to 75%). Similarly, specific volume was significantly lower in the 100% SA-CBS cupcakes, consistent with their reduced height. This marked reduction in cupcake height likely resulted from the high fiber content, which absorbed more moisture and impaired leavening by disrupting air cell formation, weakening the gluten network, and reducing gas retention [25-27]. In contrast, the height of cupcakes with 25–75% SA-CBS remained relatively stable, suggesting that moderate levels of SA-CBS did not compromise structural integrity. Specific volumes followed a similar pattern, with the 100% SA-CBS cupcake showing the lowest volume, consistent with findings that high fiber levels can impair gluten development and dilute functional proteins.

The relationships among the physical parameters of the chocolate cupcakes were examined using Pearson's correlation tests to assess the strength and direction of linear associations. Pearson correlation analyses showed that there was no significant correlation between weight and specific volume (p = 0.056), indicating that changes in weight did not correspond to changes in volume. On the other hand, there was a moderate negative correlation between cupcake height and weight (r = –0.524, p = 0.046), indicating that taller cupcakes tended to weigh less. This is in line with the findings of Ahmadi et al. [27], who noted that batter with higher fiber content tends to be heavier and denser, which can inhibit air bubble formation, limit expansion, and result in shorter, heavier cupcakes. In contrast, a strong positive correlation was found between height and specific volume (r = 0.725, p = 0.002), confirming the relationship between height and volumetric expansion. A strong positive correlation between height and specific volume highlighted the importance of proper aeration in cupcake structure, consistent with Ahmadi et al. [27] and Neeharika [28], who linked fiber addition to decreased volume in cakes due to impaired gas retention.

3.1.2 Texture Profile Analysis

Texture is a key quality parameter, influencing consumer acceptance and structural integrity. The effect of CBS concentration on cupcake hardness is presented in Table 1. Texture analysis revealed that hardness increased with higher SA-CBS substitution levels. Hardness rose from 3.65 N at 0% substitution to 5.80 N at 25% (58.90% increase), then to 10.92 N at 50% (88.28% increase from 25%), followed by a smaller increase to 11.21 N at 75% (2.66% increase), and finally to 13.93 N at 100% substitution (24.26% increase from 75%). These findings align with the study conducted by Öztürk and Ova [29], who reported firmer textures in cakes enriched with cocoa hulls. The fibrous composition of SA-CBS absorbs water, competes with other ingredients, and limits the moisture available for gluten development and starch gelatinization, resulting in a denser texture [26].

3.1.3 Color Analysis

Color measurements using CIELAB values showed significant differences, especially at higher substitution levels. Lightness (L*) increased



Figure 1. Chocolate cupcake samples formulated with varying levels of strong-alkalized cocoa bean shell (SA-CBS) powder as a substitute for commercial cocoa powder: (a) 0% SA-CBS, (b) 25% SA-CBS, (c) 50% SA-CBS, (d) 75% SA-CBS, and (e) 100% SA-CBS (no commercial cocoa powder).

Table 1.

Physical characteristics and CIELAB color parameters of chocolate cupcakes formulated with varying levels of strong-alkalized cocoa bean shell (SA-CBS) powder

Parameter	Formulation 1 0% SA-CBS	Formulation 2 25% SA-CBS	Formulation 3 50% SA-CBS	Formulation 4 75% SA-CBS	Formulation 5 100% SA-CBS
Weight (g)	48.53 ± 3.46^{a}	50.95 ± 1.07^{a}	51.95 ± 1.27^{a}	53.38 ± 4.10^{a}	55.15 ± 0.36^{a}
Height (in)	1.50 ± 0.13^{a}	1.40 ± 0.1^{ab}	1.35 ± 0.05^{ab}	1.37 ± 0.06^{ab}	1.23 ± 0.06^{b}
Specific volume (ml/g)	7.37 ± 0.61^{a}	5.11 ± 0.23^{b}	3.40 ± 0.34^{c}	4.88 ± 0.23^{b}	3.20 ± 0.12^{c}
Upper Diameter (in)	2.80 ± 0.01^{ab}	1.82 ± 0.10^{b}	2.67 ± 0.06^{ab}	2.97 ± 0.06^{a}	2.9 ± 0.1^{ab}
Lower Diameter (in)	1.73 ± 0.06^{a}	1.67 ± 0.15^{a}	1.67 ± 0.06^{a}	1.63 ± 0.06^{a}	1.43 ± 0.06^{a}
Hardness (N)	3.65 ± 0.35^{d}	5.80 ± 0.62^{c}	10.92 ± 0.41^{b}	10.73 ± 0.75^{b}	13.93 ± 0.67^{a}
Lightness (L*)	30.12 ± 1.14^{b}	31.73 ± 2.16^{ab}	32.28 ±1.79^{ab}	33.67 ±0.65^{ab}	35.45 ± 1.07^{a}
a-values (a*)	9.21 ± 0.14^{c}	9.32 ± 0.09^{c}	10.56 ± 0.44^{b}	11.73 ± 0.19^{b}	15.10 ± 0.09^{a}
b-values (b*)	8.79 ± 0.10^{c}	8.52 ± 0.04^{c}	9.99 ± 0.10^{b}	10.16 ± 0.10^{b}	15.44 ± 0.33^{a}

Mean values ± SD (n=3). Values with different superscript within the same row indicate a significant difference (p<0.05).

significantly in the 100% SA-CBS samples, indicating a lighter crumb color. Redness (a*) and yellowness (b*) also increased with higher SA-CBS concentrations. Significant differences in a* and b* values were observed between the 0% and 75%–100% groups, as well as between 0–25% and 50–75% substitution levels. Interestingly, cupcakes with 100% SA-CBS were lighter than the control, possibly due to the darker hue and higher pH (8.02) of commercial cocoa powder compared to SA-CBS powder (pH 7.64), as higher pH is associated with darker brown tones [29]. Increases in a* and b* values may also be attributed to enhanced Maillard reactions and the natural yellowish tint of SA-CBS [31,3].

Total color difference (ΔE*) values indicated perceptible changes in the following comparisons: 0% vs. 75% (4.56), 0% vs. 100% (10.36), 25% vs. 75% (3.50), 25% vs. 100% (9.75), 50% vs. 100% (7.77), and 75% vs. 100% (6.50). Other pairwise comparisons did not result in noticeable differences.

3.2 Consumer Acceptability of Chocolate Cupcakes with SA-CBS powder

Consumer acceptability of the cupcake samples, assessed by 45 untrained panelists using a 9-point hedonic scale, is presented in Table 2. Parameters evaluated included appearance, texture, taste, and overall acceptability.

3.2.1 Cupcake Appearance

Sensory evaluation confirmed instrumental findings. Appearance scores ranged from 6.89 to 6.97 for cupcakes with 0% to 75% SA-CBS powder. A significantly lower score of 5.26 was observed for the 100% SA-CBS sample. Significant differences in appearance were detected between the 100% SA-CBS sample and the 0% to 50% SA-CBS samples.

Cupcakes with 0–75% SA-CBS received favorable appearance scores (6.89–6.97), while the 100% SA-CBS cupcake received significantly lower ratings. The lighter, redder tone of the 100% sample may have appeared overbaked or artificial, negatively affecting perception [19]. A strong negative correlation between appearance scores and color parameters (L*, a*, b*) further supported this.

3.2.2 Cupcake Texture

Texture ratings for the 0% to 75% SA-CBS samples ranged from 6.17 to 6.91, while the 100% SA-CBS sample received a significantly lower score of 5.55. Significant differences were noted between the 100% SA-CBS sample and the 25% substitution levels. Texture acceptability decreased significantly at 100% SA-CBS, corresponding to increased instrumental hardness. This can be attributed to SA-CBS's high water-binding capacity and interference with gluten development, which reduce moisture retention and increase firmness [32,33]. Samples with 25–50% substitution retained a moist, spongy texture that panelists found appealing.

3.2.3 Cupcake Taste

Taste scores ranged from 6.06 to 7.15 for the 0% to 75% SA-CBS samples, with the 50% SA-CBS sample receiving the highest score. The 100% SA-CBS sample had the lowest taste rating of 5.90. Significant differences were observed between the 50% and 75% SA-CBS samples, and between the 50% and 100% SA-CBS samples. Taste scores peaked at 50% SA-CBS, while the 0%, 50%, and 75% samples were moderately acceptable. The 100% SA-CBS cupcake received the lowest score, likely due to off-flavors and slight bitterness introduced by higher SA-CBS concentrations. Lower substitution levels were described as having a sweet, chocolatey taste, which

Table 2. Mean scores of chocolate cupcake samples in the different sensory attributes during the Consumer acceptability test

Cupcake Sample	Overall Acceptability	Appearance	Texture	Taste
Formulation 1 (0% SA-CBS)	6.93 ± 1.55^{a}	6.89 ± 1.46^{a}	6.54 ± 1.53^{ab}	6.58 ± 1.61^{abc}
Formulation 2 (25% SA-CBS)	6.61 ± 1.50^{a}	6.93 ± 1.55^{a}	6.63 ± 1.39^{a}	6.97 ± 1.47^{ab}
Formulation 3 (50% SA-CBS)	7.24 ± 1.45^{a}	6.97 ± 1.44^{a}	6.91 ± 1.41^{ab}	7.15 ± 1.55^{a}
Formulation 4 (75% SA-CBS)	6.39 ± 1.22^{a}	6.65 ± 1.46^{ab}	6.17 ± 1.68^{ab}	6.06 ± 1.73^{bc}
Formulation 5 (100% SA-CBS)	6.26 ± 1.74^{a}	5.26 ± 1.53^{b}	$5.55^{B} \pm 1.70^{b}$	5.9 ± 1.85^{c}

Mean values ± SD (n=3). Values with different superscripts within the same column indicate a significant difference ($p<0.05$).

declined at higher SA-CBS inclusion levels.

3.2.4 Overall Acceptability and Panel Feedback

Overall acceptability scores ranged from 6.26 to 7.24, with no significant differences observed among the formulations. This suggests that consumer acceptance was maintained regardless of the level of SA-CBS substitution. Overall acceptability was statistically comparable across all formulations; however, the 50% SA-CBS cupcake recorded the highest numerical acceptability score. This was attributed to its moist crumb, chocolate-rich flavor, and appealing dark appearance. Panelists highlighted a slightly grainy texture and crunchy crust in higher substitution samples, identifying them as areas for potential improvement.

Panel feedback noted that the 25% and 50% SA-CBS samples had a moist texture and chocolatey flavor. Some panelists noted a slightly grainy mouthfeel and crunchy crust in the 75% and 100% SA-CBS samples. In terms of color perception, cupcakes with 0% to 50% SA-CBS were generally described as dark brown, while those with 75% and 100% substitution appeared lighter. These observations were consistent with instrumental color analysis, which showed increased L* values at higher substitution levels.

3.2.5 Correlation of Physical, Instrumental, and Sensory Attributes

To explore relationships between physical, instrumental, and sensory attributes, a heat map was generated (Figure 2). Appearance scores were strongly negatively correlated with L*, a*, and b* values, indicating a preference for darker cupcakes with lower red and yellow tones. The strong inverse correlation with a* values highlight the impact of excessive redness on appearance perception. While moderate browning is typically associated with desirable, golden-brown baked goods, excessive redness or darkness may be perceived as signs of overbaking or burnt flavors [31].

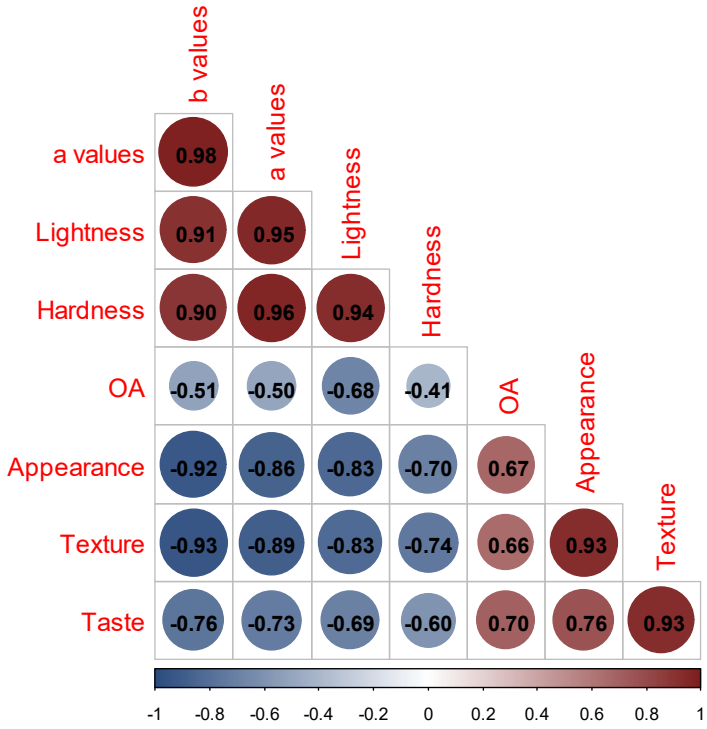


Figure 2. Heat map showing the correlation between physical measurements and sensory scores of chocolate cupcakes with varying levels of SA-CBS powder. Values range from +1 (strong positive correlation) to –1 (strong negative correlation), indicating how changes in physical attributes relate to sensory perceptions.

Similarly, elevated L* and b* values resulting from higher SA-CBS concentrations may have contributed to an undesirable yellowish or pale appearance, further reducing visual appeal. Texture scores showed a strong negative correlation with hardness, suggesting that increased hardness reduced perceived texture acceptability. This may be attributed to the drier, denser, and tougher mouthfeel associated with high levels of SA-CBS powder, a consequence of its high fiber content.

3.2.6 Selection of the most desirable cupcake formulation

Based on the results of the consumer acceptability test, the 50% SA-CBS cupcake was selected for further proximate analysis. Although overall acceptability was similar among most samples, only the 0%, 25%, and 50% SA-CBS samples showed no significant differences in appearance, taste, and texture scores. The 50% substitution level was selected based on favorable panelist feedback, which emphasized its moist texture, rich chocolate flavor, and dark appearance. Thus, the 50% SA-CBS cupcake was selected for proximate analysis as it balanced favorable sensory attributes with maximum SA-CBS incorporation.

3.3 Proximate Analysis of the most desirable cupcake formulation

The proximate composition of the 50% SA-CBS cupcake formulation is presented in Table 3. Parameters analyzed included moisture, ash, crude fat, crude fiber, crude protein, nitrogen-free extract (NFE), and total sugar content.

The moisture content of the 50% SA-CBS cupcake was 39.50%. Ash content was measured at 2.58 ± 0.15%, indicating a relatively high mineral content. Crude fat content was 24.75 ± 0.28%, and crude fiber was 0.2416 ± 0.01%. Crude protein content reached 20.65 ± 0.12%, while the nitrogen-free extract (NFE) was 12.27 ± 0.76%. Total sugar content was 250.55 ± 14.20 mg/g. Its proximate composition showed a moisture content which was slightly higher than typical ranges, which may have enhanced freshness and mouthfeel [34]. Ash content reflected the mineral-rich nature of SA-CBS, especially its potassium and magnesium content [35]. Fat content (24.75%) largely originated from butter and oil, while the SA-CBS powder contributed minimally [36]. The measured crude fiber (0.24%) highlighted the potential of SA-CBS as a functional ingredient for dietary fiber enrichment [5]. Protein content (20.65%) resulted from the combined contributions of eggs and SA-CBS, which provide moderate protein levels [35]. The nitrogen-free extract and total sugar levels reflected contributions from wheat flour and sugar in the cupcake formulation [37].

Table 3. Proximate composition of chocolate cupcake sample with 50% SA-CBS substitution

Parameter	
Moisture Content (%)	39.50 ± 0.45
Ash Content (%)	2.58 ± 0.15
Fat Content (%)	24.75 ± 0.28
Fiber Content (%)	0.2416 ± 0.01
Protein Content (%)	20.65 ± 0.12
Nitrogen-Free Extracts (%)	12.27 ± 0.76
Total Sugars (mg/g)	250.55 ± 14.20

Mean values ± SD (n=3)

CONCLUSION

This study formulated chocolate cupcakes by substituting cocoa powder with varying levels of strong-alkalized cocoa bean shell (SA-CBS) powder. Results showed that SA-CBS significantly affected the physicochemical and sensory properties of the product, particularly at higher substitution levels. Specific volume, texture, and color were most impacted, with 100% substitution resulting in denser, less appealing cupcakes. The 50% SA-CBS formulation emerged as the optimal level, maintaining desirable sensory qualities, such as moist texture, rich chocolate flavor, and acceptable appearance, while providing a proximate composition that supports its potential as a value-added bakery product. Proximate analysis of this formulation revealed 39.50% moisture, 2.58% ash, 24.75% fat, 0.24% fiber, 20.65% protein, 250.55 mg/g total sugars, and 12.27% nitrogen-free extracts, supporting its potential as a nutrient-enriched bakery product.

These findings highlight the potential of SA-CBS powder as a functional ingredient in cocoa-based baked goods. Its incorporation offers a sustainable, cost-effective alternative to traditional cocoa powder. Importantly, the 50% substitution level preserved key sensory attributes, ensuring consumer acceptability. This research adds to the expanding literature on cocoa bean shell valorization, showcasing its effective incorporation in baked product formulations. With its favorable nutritional profile, sensory performance, and sustainability potential, SA-CBS can support the development of healthier, more resource-efficient food products.

Author Contributions: Eliezer Jr. P. Valencia contributed to writing the original draft preparation, reviewing, and editing

of the manuscript, conceptualization of the study design, data curation through management and organization of research data, formal analysis of the study findings, hands-on investigation, and the development of the methodology used in the study. Argel Largado was responsible for data curation, assisted in performing formal analysis, and assisted in project administration, including coordination and execution of study activities. John Joseph Menia contributed to data curation, assisted in performing formal analysis, and supported project administration by managing day-to-day project tasks. Romel Felismino provided contributions in the conceptualization of the study, secured project funding, and supervised the research process to ensure scientific rigor and integrity. Katherine Ann Castillo-Israel contributed to conceptualization and participated in funding acquisition and overall supervision of the project. Sheba Mae Duque took part in writing, review, and editing of the manuscript, conceptualized aspects of the research, acquired funding, and oversaw project administration and supervision across all phases of the study. All authors have reviewed and approved the manuscript for publication.

Funding: The authors sincerely acknowledge the research funding support from the Department of Science and Technology–Philippine Council for Health Research and Development (DOST-PCHRD).

Data Availability Statement: The datasets that were generated and analyzed during the study are available from the corresponding author upon reasonable request.

Acknowledgments: This study is part of the "Cocoa-Loca Project: Development of functional food products and ingredients from CBS waste" under the Collaborative Research and Development to Leverage the Philippine Economy (CRADLE) program funded by the Department of Science and Technology-Philippine Council for Health Research and Development (DOST-PCHRD), in partnership with the Malagos Agri-Ventures Corporation and University of the Philippines Los Baños.

Conflicts of Interest: The authors affirm that they do not hold any conflict of interest.

Ethical Statement: The Research Ethics Review Committee of Mary Mediatrix Medical Center reviewed and approved this study, assigning it the protocol code MMMC-RERC 0005-05-2024. Informed consent was obtained from all participants, and all data were anonymized to ensure confidentiality. All procedures adhered to ethical guidelines set forth by the ICH-GHCP and were reviewed and approved by the aforementioned review board. This work was supported by the Department of Science and Technology under Collaborative Research and Development to Leverage Philippine Economy (DOST-CRADLE) Program.

REFERENCES

1. DEPARTMENT OF AGRICULTURE, & DEPARTMENT OF TRADE AND INDUSTRY. 2017-2022 Philippine Cacao Road Map, 2017, Available online: https://www.da.gov.ph/wp-content/uploads/2018/01/Philippine-Cacao-Industry-Roadmap.pdf (Accessed on 2 October 2023)
2. GRILLO, G., BOFFA, L., BINELLO, A., MANTEGNA, S., CRAVOTTO, G., CHEMAT, F., DIZHBITE, T., LAUBERTE, L., and TELYSHEVA, G. Cocoa bean shell waste valorisation; extraction from lab to pilot-scale cavitational reactors. *Food Research International* 2019, 115: 200–208. https://doi.org/10.1016/j.foodres.2018.08.057
3. SOUZA, F.N.S, VIEIRA, S.R., CAMPIDELLI, M.L.L., ROCHA, R.A.R., RODRIGUES, L.M.A., SANTOS, P.H., CARNEIRO, J.D.D.S.C., and TAVARES, M.D.C.I. Impact of using cocoa bean shell powder as a substitute for wheat flour on some chocolate cake properties. *Food Chemistry* 2022, 381: 132215. https://doi.org/10.1016/j.foodchem.2022.132215
4. DE BARROS, H.E.A., NATARELLI, C.V.L., TAVARES, I. M.DEC., DE OLIVEIRA, A. L. M., ARAÚJO, A. B. S., PEREIRA, J., CARVALHO, E. E. N., BOAS, E. V. DE B. V., and FRANCO, M. Nutritional Clustering of Cookies Developed with Cocoa Shell, Soy, and Green Banana Flours Using Exploratory Methods. *Food and Bioprocess Technology* 2020, 13(9): 1566–1578. https://doi.org/10.1007/s11947-020-02495-w
5. HANDOJO, L., TRIHARYOGI, H., and INDARTO, A. Cocoa bean shell waste as a potential raw material for dietary fiber powder. *International Journal of Recycling of Organic Waste in Agriculture* 2019, 8(S1): 485–491. https://doi.org/10.1007/s40093-019-0271-9
6. BARIŠIĆ, V., JOZINOVIĆ, A., FLANJAK, I., ŠUBARIĆ, D., BABIĆ, J., MILIČEVIĆ, B., DOKO, K., and AČKAR, Đ. Difficulties with Use of Cocoa Bean Shell in Food Production and High Voltage Electrical Discharge as a Possible Solution. *Sustainability* 2020, 12(10): 3981-3981. https://doi.org/10.3390/su12103981.
7. BATISTA, J.E., BRAGA, L.P., OLIVEIRA, R.C., SILVA, P.E., and DAMIANI, C. Partial replacement of wheat flour by pumpkin seed flour in the production of cupcakes filled with carob. *Food Science and Technology* 2018, 38(2): 250–254. https://doi.org/10.1590/1678
8. KOSTIC, M.J. Cocoa alkalization. *The Manufacturing Confectioner* 1997, 77: 128–130.
9. CHAU, E., ARROYO, A.T., and ARANA, J.V. Optimization of the general acceptability through

affective tests and response surface methodology of a dry cacao powder mixture-based beverage. *Scientia Agropecuaria* 2013, 4: 191–197. https://doi.org/10.17268/sci.agropecu.2013.03.05

10. INTERNATIONAL COCOA ORGANIZATION (ICCO). Global cocoa production and waste statistics. 2017, Available online: www.icco.org (Accessed on 21 March 2024)

11. DUQUE, S.M.M., QUEJADAS, K.C.B., AND LARGADO, A.A. Valorization of cocoa bean shell waste through sustainable extraction of phenolics: Process optimization and characterization. *Science and Engineering Journal* 2024, 17(02): 245-256. https://doi.org/10.54645/2024172IOD-33

12. MILLER K.B., HURST W.J., PAYNE M.J., STUART D.A., APGAR J., SWEIGART D.S., and OU B. Impact of alkalization on the antioxidant and flavanol content of commercial cocoa powders. *J Agric Food Chem* 2008, 56(18): 8527–33. https://doi.org/10.1021/jf801670p.

13. BITRUS, J., AMADI, O.C., NWAGU, T.N., NNAMCHI, C.I., AND MONEKE, A.N. Application of wild yeast (*Saccharomyces cerevisiae*) isolates from palm wine and honey in baking of cassava/wheat composite bread. *Food and Nutrition Sciences* 2020, 11(7): 895–911. https://doi.org/10.4236/fns.2020.117050

14. LIU, S., CHEN, D., AND XU, J. The effect of partially substituted lupin, soybean, and navy bean flours on wheat bread quality. *Food and Nutrition Sciences* 2018, 9(7): 840–854. https://doi.org/10.4236/fns.2018.97063

15. ŠEBESTÍKOVÁ, R., BUREŠOVÁ, I., VYHNÁNEK, T., MARTINEK, P., and POSPIECH, M. Rheological and fermentation properties of doughs and quality of breads from colored wheat varieties. *Heliyon* 2023, 9(4): e15118–e15118. https://doi.org/10.1016/j.heliyon.2023.e15118.

16. TINCHAN, P., DECHKUNCHORN, M., and KAEWKA, K. 2019. Effect of corn milk by-product addition on the physical properties of whole wheat bread. *Chiang Mai University Journal of Sciences* 2019, 18 (1): e2019008. https://doi.org/10.12982/CMUJNS.2019.0008

17. OLAERTS, H., DE BONDT, Y., and COURTIN, C.M. Density Separation as a Strategy to Reduce the Enzyme Load of Preharvest Sprouted Wheat and Enhance Its Bread Making Quality. *Food Chemistry* 2018, 241: 434–42. https://doi.org/10.1016/j.foodchem.2017.09.027.

18. PRADHAN, A., and TRIPATHY, P.P. Effect of little millet (*Panicum miliare*) on physical, rheological, nutritional, and microstructural properties of bread. *Journal of Food Processing and Preservation* 2022, 46(8): e16782. https://doi.org/10.1111/jfpp.16782

19. BOTOSOA, E.P., CHÉNÉ, C., and KAROUI, R. Monitoring changes in sponge cakes during aging by front face fluorescence spectroscopy and instrumental techniques. *Journal of Agricultural and Food Chemistry* 2013, 61(11): 2687–2695. https://doi.org/10.1021/jf3048115

20. AOAC. Official methods of analysis (Vol. I and II). Association of Official Analytical Chemists, 2000, Washington, D.C.

21. TAMBOLI, F.A., MORE, H.N., BHANDUGARE, S.S., PATIL, A.S., JADHAV, N.R., and KILLEDAR, S.G. Estimation of Total Carbohydrate content by Phenol Sulphuric acid Method from Eichhornia crassipes (Mart.) Solms. *Asian Journal of Research in Chemistry* 2020, 13(5): 357–359. https://doi.org/10.5958/0974-4150.2020.00067.x

22. MAJZOOBI, M., HABIBI, M., HEDAYATI, S., and FARAHNAKY, A. Effects of commercial oat fiber on characteristics of batter and sponge cake. *Journal of Agricultural Science and Technology* 2015, 17: 99-107.

23. GAO, Y., MA, D., JIANG, S., MA, Y., LI, S., WANG, K., and XU, X. A novel oven structure for improving temperature uniformity of vapor cell in atomic sensors. *Results in Physics* 2023, 47: 106339. https://doi.org/10.1016/j.rinp.2023.106339

24. KHATER, E.G. and BAHNASAWY, A.H. Heat and Mass Balance for Baking Process. *J Bioprocess Biotech* 2014, 4: 190 https://doi.org/10.4172/2155-9821.1000190

25. HE, Y., WANG, B., WEN, L., WANG, F., YU, H., CHEN, D., SU, X., and ZHANG, C. Effects of dietary fiber on human health. *Food Science and Human Wellness* 2022, 11(1): 1–10. https://doi.org/10.1016/j.fshw.2021.07.001

26. AYDOGDU, A., SUMNU, G., and SAHIN, S. Effects of addition of different fibers on rheological characteristics of cake batter and quality of cakes. *Journal of Food Science and Technology,* 2017 55(2): 667–677. https://doi.org/10.1007/s13197-017-2976-y

27. AHMADI, F., AGHAJANI, N., and ARDABILI, A.G. Response surface optimization of cupcake physicochemical and sensory attributes during storage period: Effect of apricot kernel flour addition.

Food Science and Nutrition 2021, 10(3): 661–677. https://doi.org/10.1002/fsn3.2688

28. NEEHARIKA, B.G. Leavening agents for food industry. *International Journal of Current Microbiology and Applied Sciences* 2020, 9(9): 1812-1817. https://doi.org/10.20546/ijcmas.2020.909.227

29. ÖZTÜRK, E. and OVA, G. Cocoa Bean Hulls: Effect on Nutritional Quality, Texture and Sensory Properties of Pound Cake. *Türk tarım - gıda bilim ve teknoloji dergisi* 2020, 8(3): 560–567. https://doi.org/10.24925/turjaf.v8i3.560-567.2865.

30. GARCÍA, D.V., PÉREZ-ESTEVE, E., and BARAT, M. Changes in cocoa properties induced by the alkalization process: A review. *Comprehensive Reviews in Food Science and Food Safety* 2020, 19(4): 2200–2221. https://doi.org/10.1111/1541-4337.12581.

31. PURLIS, E. Browning development in bakery products – A review. *Journal of Food Engineering*, 2010 *99*(3), 239–249. https://doi.org/10.1016/j.jfoodeng.2010.03.008

32. AGUILERA, J.M., and D.W. STANLEY. *Microstructural Principles of Food Processing and Engineering* 1989, London, UK: Elsevier Applied Science.

33. MATOS, M.E., and ROSELL, C.M. Understanding gluten-free dough for reaching breads with physical quality and nutritional balance. *Journal of the Science of Food and Agriculture* 2014, 95(4), 653–661. https://doi.org/10.1002/jsfa.6732

34. MONTES, N.D., and TRINDADE, M.A. Estimating sensory shelf life of chocolate and carrot cupcakes using acceptance tests. *Journal of sensory studies* 2010, 25(2): 260–279. https://doi.org/10.1111/j.1745-459x.2009.00256.x

35. ROJO-POVEDA, O., BARBOSA-PEREIRA, L., ZEPPA, G., and STÉVIGNY, C. Cocoa Bean Shell-A By-Product with Nutritional Properties and Biofunctional Potential. *Nutrients* 2020, 12(4). https://doi.org/10.3390/nu12041123

36. MEHTA, N., KUMAR, P., VERMA, A.K., UMARAW, P., and KUMAR, Y. Microencapsulation as a noble technique for the application of bioactive compounds in the food industry: A comprehensive review. *Applied Sciences* 2022, 12(3): 1424. https://doi.org/10.3390/app12031424

37. LEONG SY, DUQUE SM, MUHAMMAD B, OEY I. 2019 Carbohydrates. *Innovative Thermal and Non-thermal Processing and Bioavailability of Nutrients and Bioactive compounds* 2019, 171-206.https://doi.org/10.1016/B978-0-12-814174-8.00006-8.

Disclaimer/Publisher's Note: The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of CMUJS and/or the editor(s). CMUJS and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.

CMU Journal of Science
The Official Scientific Journal of Central Mindanao University
ISSN Print: 0116-7847 js.cmu.edu.ph ISSN Online: 2704-3703

Research Article

An Internet of Things-based Traffic Light Control Using Computer Vision for Real-time Traffic Density Calculation

Josh Ivan M. Caramat[1], Princess Leila R. Ditchon[2], Julie Ann C. Lontoc[3], Ivan Neil B. Tapel[4]

1 Department of Information Technology Cavite State University - Main Campus, Cavite, Philippines; joshivan.caramat@cvsu.edu.ph

2 Department of Information Technology Cavite State University - Main Campus, Cavite, Philippines; princessleila.ditchon@cvsu.edu.ph

3 Department of Information Technology Cavite State University - Main Campus, Cavite, Philippines; jclontoc@cvsu.edu.ph

4 Department of Information Technology Cavite State University - Main Campus, Cavite, Philippines; ivanneil.tapel@cvsu.edu.ph

ABSTRACT.

The use of traditional traffic light timers in the Philippines has limitations in addressing dynamic fluctuations of traffic density. This observation prompted the study to design an adaptive traffic light system. While most existing research has focused on vehicle counts as a basis for adjusting traffic signals, few studies have utilized computer vision to consider vehicle occupancy for the same purpose. Moreover, the use of emerging computer vision technologies in this context warrants further exploration. In response, the researchers developed a system capable of adjusting traffic light timing based on real-time traffic density calculated through computer vision. The system gathers live traffic feeds and employs a YOLOv8-based model to detect and classify vehicles, thereby identifying current traffic conditions. A prototype was developed to simulate a traffic light system integrated with the Internet of Things (IoT). Results show that the model can detect and classify vehicles into four categories with a mean Average Precision (mAP@0.50) of 0.94. These findings demonstrate the potential of the proposed system as a precursor to the actual implementation of adaptive traffic lights and improvement of urban traffic management.

Keywords: Traffic light control, computer vision, traffic density, YOLOv8, traffic management

Citation: Caramat, J. I., Ditchon, P. L., Lontoc, J. A., & Tapel, I. N. (2026). An Internet of Things-based Traffic Light Control System Utilizing Computer Vision for Real-time Traffic Density Calculation. *CMU Journal of Science*, *30*(1), 63

Academic Editor: Dr. Einstine M. Opiso

Received: Nov. 23, 2025
Revised: June 2, 2026
Accepted: June 9, 2026
Published: July 2, 2026

Copyright: © 2024 by the authors. Submitted for possible open access publication under the terms and conditions of the Creative Commons Attribution (CC BY) license (https://creativecommons.org/licenses/by/4.0/).

INTRODUCTION

Efficient transportation plays a crucial role in sustaining economic activity, social connectivity, and overall urban development [17]. However, many major roads in the Philippines experience chronic traffic congestion that reduces travel speed, increases fuel consumption, and degrades air quality. Traffic congestion occurs when the number or movement of vehicles exceeds road capacity, causing extended travel times and inefficiencies in traffic flow [5]. This condition underscores the pressing need for traffic management systems that can adapt to real-time conditions, rather than relying solely on fixed-time control strategies.

Traditional traffic-signal controllers typically operate on preprogrammed timing plans that do not adjust to fluctuating vehicle volumes. As urban traffic becomes increasingly complex, static signal timers often fail to account for the varying vehicle types, occupancy rates, and road demands. These inefficiencies often lead to increased delays and conflict points at intersections [17]. Recent studies have emphasized the importance of adopting proactive and data-driven solutions to improve intersection safety and overall traffic operations [1].

In the Philippine context, [16] reported that Metro Manila consistently ranks among the most congested urban areas in Southeast Asia, with economic and environmental impacts extending to adjacent provinces. Local studies also emphasize the importance of integrating sustainable mobility measures and technological innovations into traffic systems to support long-term development objectives [4].

Meanwhile, research on shared mobility and multimodal integration highlights the role of intelligent transport systems in addressing last-mile and network efficiency issues. [7] emphasized that shared-mobility and data-driven transport strategies can alleviate congestion and promote urban efficiency. Similarly, [6] proposed a conceptual framework for integrating transport demand modeling with emerging technologies, which aligns with adaptive traffic-signal control systems.

With the advancement of computer vision and Internet of Things (IoT) technologies, real-time vehicle detection and classification have become more accurate and accessible. Studies on traffic-density estimation suggest that area-based occupancy and vehicle classification can yield more reliable density metrics than traditional vehicle-count approaches [12]. These technologies can provide dynamic data that can be directly linked to signal timing algorithms.

In response to these developments, this study proposes an IoT-enabled adaptive traffic light control system that utilizes a YOLOv8-based computer vision model to detect and classify vehicles and compute real-time traffic density. The system aims to provide accurate, real-time density estimates that account for vehicle types and sizes; allocate signal time dynamically based on traffic demand; and demonstrate a working prototype integrating a vision-based detection model with an Arduino-based controller. This project serves as a proof-of-concept for an adaptive signal control system that can potentially improve traffic efficiency and serve as a precursor for real-world implementation.

METHODOLOGY

To enable the model to detect and classify vehicles accurately, several development stages were undertaken. The process involved data collection, preprocessing, model training, and system integration using the YOLOv8 algorithm. This section describes each stage of development and the construction of the IoT-based traffic-light control prototype.

Model Development

Data and Data Collection

The researchers used a modified classification from the Toll Regulatory Board (TRB) to include motorcycles with under 400 cubic capacities (cc), since the program will be tested at an intersection with no cubic capacity limitations. The researchers created a new classification of vehicles, as shown in Table 1. The researchers manually recorded videos of the incoming vehicles at the intersection to collect data. A smartphone (iPhone 14 Pro Max) was used to record the videos for the dataset. The video resolution was set to 1280x720 pixels with 30 frames per second. The researchers gathered 1000 images of each vehicle classification and incremented by 200 more images in each increment depending on the performance and accuracy of the model. The dataset was split based on training, validation, and test set to be fed in training a model for vehicle classification. This dataset size is sufficient in comparison with [15] where they collected 800 images for six (6) vehicle classifications totaling to 4800 images created.

Additionally, [9] conducted similar study utilizing 425 images per 10 vehicle models per approach (fine-tuning: Inception-v3, MobileNet-v2, and ResNet-18; and extraction: AlexNet). These approaches yielded 95.7% - 97.4% accuracy for fine-tuning and 93.5% accuracy for extraction. Given these, 1000 dataset per vehicle classification is valid and sufficient to yield high accuracy in the performance of the model. In Table 2, dataset was divided into training, validation, and test sets to be used to train the model for vehicle classification. This is in line with [14] that 70%/20%/10% split for train, validation, and test set is recommended for machine learning.

Table 1. Vehicle Classification

Class	Description	Examples
1	Lightweight vehicles with only two wheels.	Motorcycles, Bicycles, Scooters
2	Vehicles with two axles and a height not exceeding 7 feet 5 inches (2,286 mm).	Cars, Jeepneys, Vans, Pick-ups
3	Vehicles that exceed 7 feet 5 inches in height with two axles.	Buses, Trucks
4	Trucks with three or more axles and a height greater than 7.5 feet.	Large Trucks, Large Trucks with Trailers

Table 2. Dataset split

TRAIN SET	70%
VALIDATION SET	20%
TEST SET	10%

Data Preprocessing

The researchers utilized Roboflow [11] for the annotation of the datasets. The video was split into a one-frame-per-second format, creating one image for every second of the video. The researchers manually labeled the datasets by drawing bounding boxes around each vehicle. The images then underwent preprocessing procedures through Roboflow. Each image was resized to 1080 x 640 pixels to allow smaller file sizes and faster training. Lastly, the images were augmented by adjusting the exposure by -20% and +20%.

Model Training

The preprocessed datasets were exported and uploaded to Google Colab [3] for model training. Google Colab is hosted by the Jupyter Notebook service, which provides free access to computing resources, including Tensor Processing Units (TPUs) and Graphics Processing Units (GPUs). It is widely used in machine learning, data science, and education. Inside Google Colab, a Jupyter notebook will be uploaded for training the model. The YOLOv8 network has been designed to meet different needs, resulting in models of various sizes. The small-size model (yolov8s.pt) was chosen for training because it offers a good balance between accuracy and computational efficiency [7]. Additionally, [10] argued that YOLOv8 achieves superior inference speed while maintaining accuracy, enabling frame-by-frame vehicle detection in live video streams, and studies conclude that YOLOv8 outshines other YOLO variants (v3, v4, v5, and v7) in many aspects including speed and accuracy for traffic purposes. Moreover, [9] demonstrated the effectiveness of yolov8-based vehicle detection model trained on a 2,500-image Veh5 dataset achieving score results of mAP50 = 0.994 and mAP50–95 = 0.915.

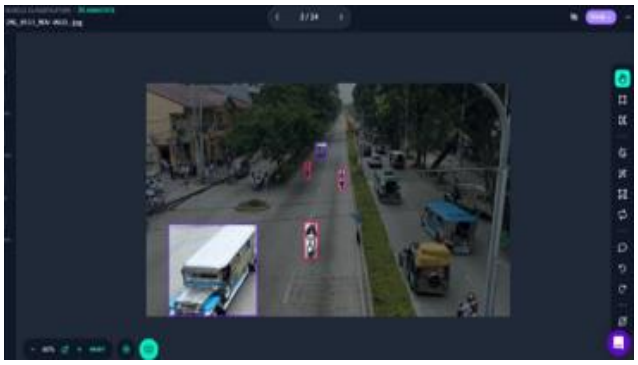


Figure 1. Roboflow Annotation Interface

IoT Traffic Light Control Prototype

System Architecture

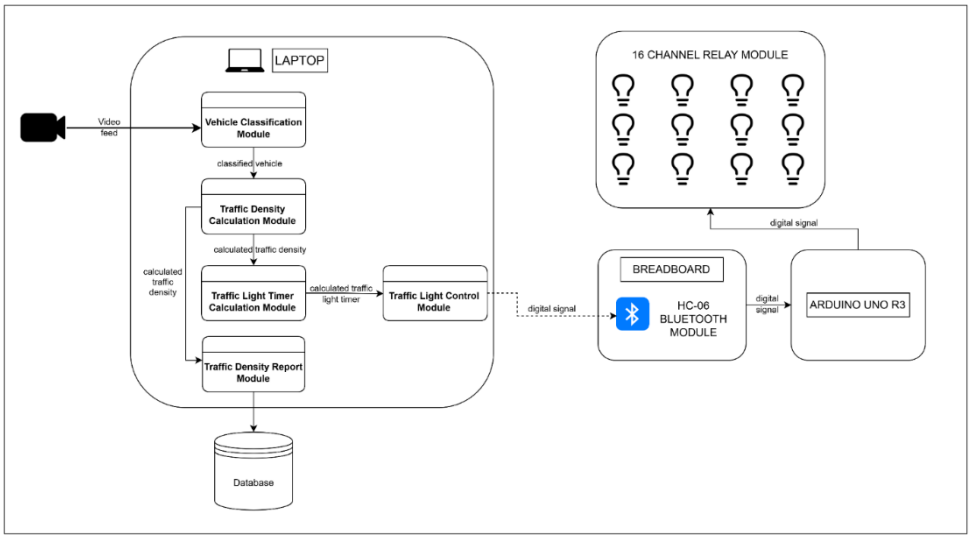


Figure 2. System Architecture

Figure 2 presents the system architecture of the study. It was developed to be modular and layered to ensure efficiency in real-time analysis and control of traffic. The system consists of several modules primarily responsible for traffic light control, traffic density calculation, and traffic light timing. This architecture includes a laptop for processing and an Arduino Uno R3 for control.

The laptop handles the software modules, while Arduino Uno R3 and the Bluetooth module operate the traffic lights through a relay module. The modules within the system are discussed as follows:

Vehicle classification module: Processes video feeds from real-time camera input and recorded traffic footage to classify vehicle types using the developed model. This module identifies the classified vehicles and their occupied area, which serves as input for calculating traffic density. The ROI must be defined to limit detection and classification within a specified area.

Traffic density calculation module: Calculates the traffic density. The traffic density (D_1) is calculated by the total area occupied by the vehicle ($TA_(veh_)$) over the area of the region of interest (AROI) multiplied by 100 (Eq. 1).

$$D_i = (TA_{veh}/A_{ROI})100$$

To determine the area of each vehicle, the researchers gathered information about average vehicle dimensions and utilized the data shown in Figure 3, produced by the study of [9].

Class	Description	Pictorial representation of vehicle class	Length (m)	Width (m)	Area (m^2)	Ave. Class Area (m^2)
1	Motorized Two-Wheeler		1.65	0.76	1.25	1.25
2	Small Car / Passenger Car		3,84	1.45	5.57	6.6
	Big Car, Sports Utility Vehicles, etc.		4.60	1.80	8.28	
	Small-Sized Commercial Goods Vehicles		4.36	1.38	6.02	
3	Light-weight Commercial Goods Vehicles		5.62	1.52	8.54	13.38
	2-Axle Rigid Trucks/ Buses		8.28	2.20	18.22	
4	3-Axle Rigid Trucks/ Buses		9.10	2.30	20.93	25.74
	4-Axle, 5-Axle and 6-Axle Trucks		12.62	2.42	30.54	

Figure 3. Average Area of Each Vehicle Classification

Traffic light timer module. Sets the red and green light timers based on the calculated traffic density. It produces computed timer values for both red and green lights, which are sent to the Arduino Uno R3 microcontroller via the HC-07 Bluetooth module. Green light durations are determined according to the level of traffic congestion (see Table 2).

Traffic light control module: Composed of hardware components such as Arduino Uno R3 microcontroller, HC-06 Bluetooth module, 16-channel 5V relay module, and E27 light bulbs. The allocated timer is received by the microcontroller through the Bluetooth module, which controls the lightbulb duration using the relay module.

Traffic density report module: Create records of traffic density patterns. The database logs information such as lane number, vehicle classes, traffic density level, hour, minute, day, date, month, year, and the calculated traffic density at a specific time.

Table 3. Lane Green Light Timers

Level of Traffic	Traffic Density Percentage	Green Light Timer
	Lane 1	
Low	$D1 \leq 33.333\%$	21
Moderate	$33.333\% < D1 > 66.666\%$	42
High	$66.666\% < D1 > 100\%$	65
	Lane 2	
Low	$D2 \leq 33.333\%$	35
Moderate	$33.333\% < D2 > 66.666\%$	70
High	$66.666\% < D2 > 100\%$	105
	Lane 3	
Low	$D3 \leq 33.333\%$	11
Moderate	$33.333\% < D3 > 66.666\%$	22
High	$66.666\% < D3 > 100\%$	35
	Lane 4	
Low	$D4 \leq 33.333\%$	13
Moderate	$33.333\% < D4 > 66.666\%$	26
High	$66.666\% < D4 > 100\%$	40

Set-up

The prototype IoT traffic light control system is composed of different hardware materials, including the Arduino UNO, Bluetooth Relay Module, 16 Channel 5V Relay Module, and bulbs that serve as the traffic light signals, as shown in Figure 4.

Arduino and Bluetooth Module: The Bluetooth module allows a wireless connection with the Python program. The module sends data to the Arduino to trigger the bulbs. The digital pins are connected to the RXD and TXD pins of the Bluetooth module for data transfer to the Arduino, while the VCC and GND pins provide power. Since the Arduino uses a 5V trigger, the researchers used two 1k Ohm resistors as a voltage divider to stabilize the input voltage for the Bluetooth module.

Arduino and 16 Channel 5v Relay: Since the relay module is a low-level trigger, it is activated using a low signal from the microcontroller. To supply the Arduino with power, the researchers utilized the 5v output from the relay module and connected it to the VIN port of the Arduino. Additionally, controlling the relay required connecting the input pins of the relay module to the Arduino's digital pins.

16 Channel 5v Relay Module to 5v Bulbs: Each positive wire of the bulbs was connected to the Normally Open (NO) terminal of the relay module. The ground wires were connected sequentially to one another until the last bulb. Lastly, the Common ports of the relay module were interconnected, resulting in two wires extending from the last common port and joining with the ground wire of the bulb. These two wires were then connected to a power plug for the AC power source.

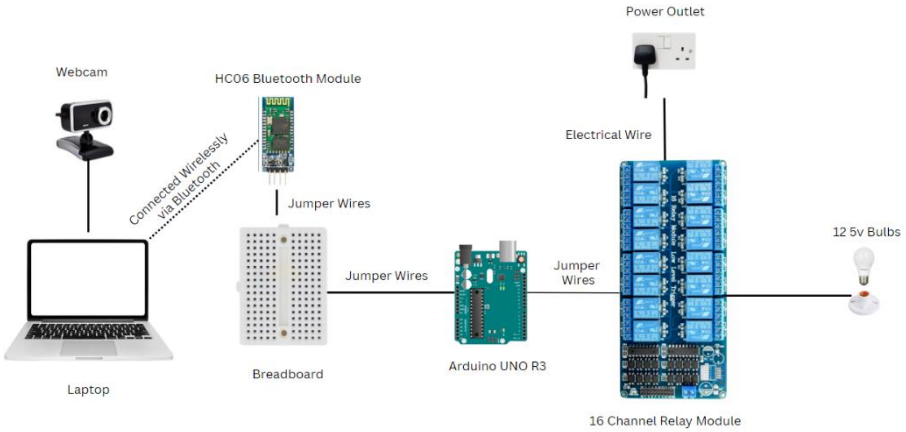
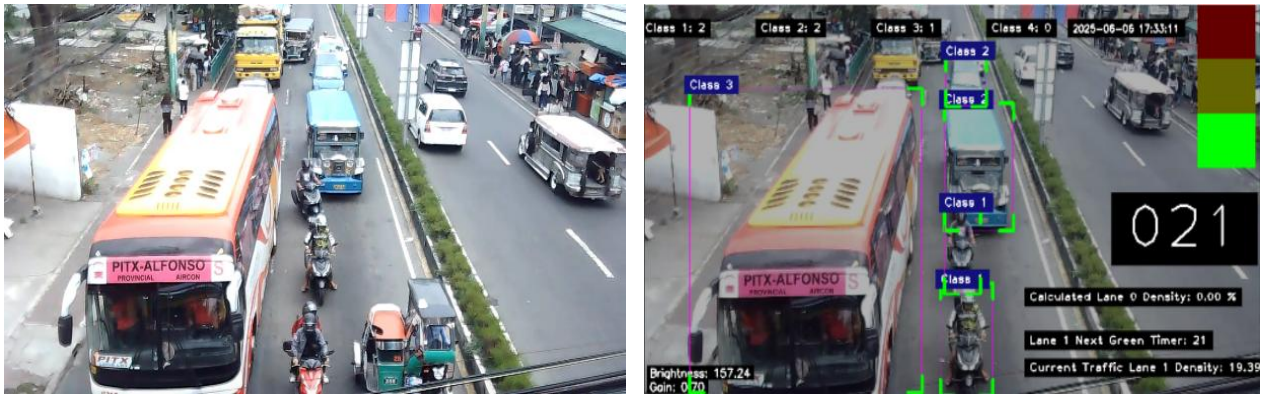


Figure 4. Diagram of prototype IoT Traffic Light Control

RESULTS AND DISCUSSION

3.1 YOLOv8-Based Vehicle Classification Model

The latest version of the developed model successfully performed its intended function of detecting vehicles. The model consistently classified the detected vehicles from a traffic video within the ROI and provided these classifications as input variables to the program, which then calculated the traffic density and adjusted the traffic light timer accordingly, as shown in Figure 5.



(a) (b)

Figure 5. Raw traffic image (a) and traffic image in the system with the corresponding light timer (b)

There were instances of vehicle occlusion observed during testing in the earlier versions of the model. Specifically, Class 1 vehicles were more likely to be occluded, suggesting that the model requires additional datasets containing more instances of Class 1 vehicles, as shown in Figure 6.

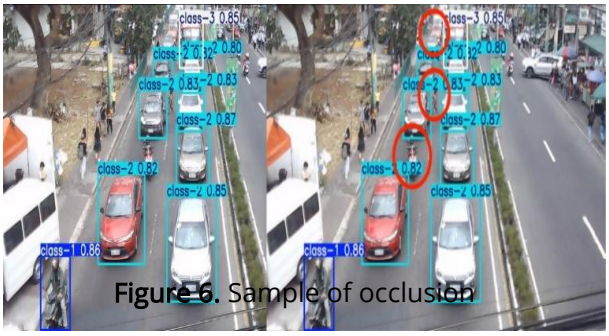


Figure 6. Sample of occlusion

To address this issue, the researchers gathered additional datasets that included more instances of Class 1 vehicles and applied hyperparameter tuning, which helped improve the model's detection performance in the later versions. In addition, the most recently trained model was fine-tuned to further enhance its overall performance.

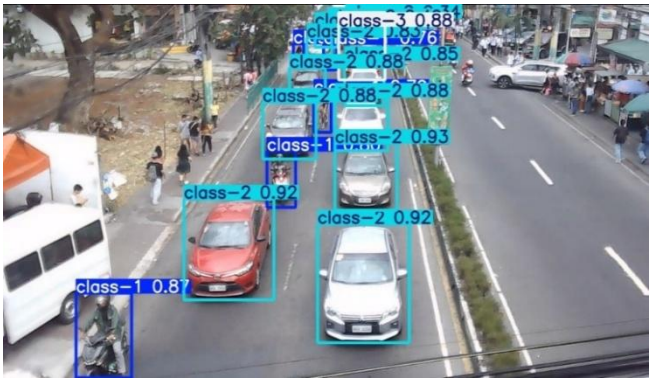


Figure 7. Sample of the detection of the final version

The trained model gained at most 91.4% mAP@50 and 67.1% mAP@[50:95] which shows low loss values and high precision and recall. To further improve the model, the researchers fine-tuned the latest model which resulted to 94% mAP@50 and 69.7% mAP@[50:95] based on the prepared validation data sets gathered in Dasmarinas with four lane intersection. Figure 8 presented the evaluation metrics result of the latest version before and after fine-tuning.

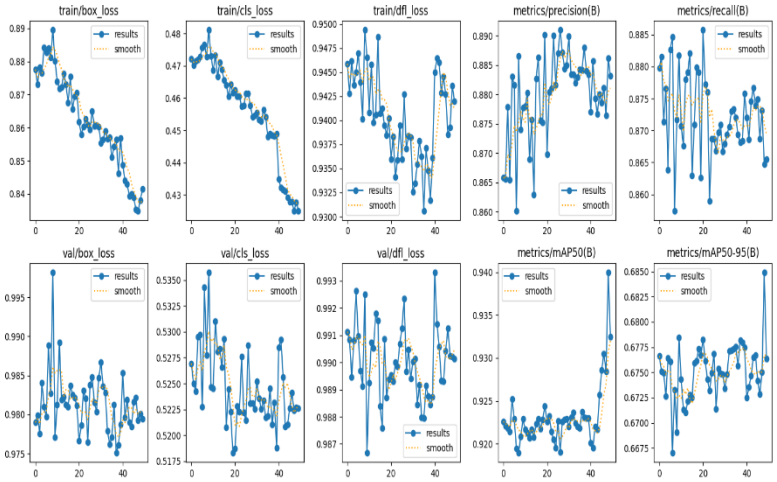


Figure 8. Evaluation of the latest version of the developed YOLOv8 model

Prototype IoT Traffic Light Control

The ROI utilized in the system is based on the camera's viewing range from the footbridge overlooking the traffic, as shown in Table 3. The ROI is set within the vehicle classification module. The Arduino Uno is programmed to fetch and display the appropriate light pattern. Figures 9 and 10 present the IoT Traffic light control prototype.

The prototype of the Internet of Things (IoT)-enabled traffic light control system functioned as designed. The camera operated as the "eye" of the system, capturing live traffic that was integrated into the program, which then produced a video output with vehicle detection and classification within the ROI.

Table 3. Adjusted ROI for each lane

Lane	Length (m)	Width (m)	Area (m^2)
1	25	6	150
2	25	6	150
3	25	9	225
4	25	6	150



Figure 9. A prototype of Internet of Things-based traffic light control showing ROI



Figure 10. A prototype of Internet of Things-based traffic light control showing output based on video feed

The prototype of Internet of Things-enabled traffic light control fulfills the purpose of simulating traffic light. The prototype underwent unit testing and integration testing that ensures the suitability of the assembled output for the expected outcome. System testing was done to evaluate the capability of the system in terms of speed to test its operation capacity in real-time environment. Results showed the highest frame per second (FPS) recorded is 20 FPS. On the other hand, the best inference speed is 20.77ms, and the average inference time is 28.49ms but appears to be lower in a lower GPU. This shows that the capacity of the system (FPS and inference speed) to operate is dependent on the GPU used.

CONCLUSION

This study demonstrated that utilizing computer vision enables adaptive traffic light management. The YOLOv8 algorithm was employed to create a vehicle detection model that can categorize vehicles into distinct types. Using the model's output, the system determined the average area of vehicles to calculate traffic density. The study produced an Internet of Things (IoT)-based traffic light control prototype that incorporated the vehicle detection model. The camera, which served as the "eye" of the prototype, transmitted live traffic feeds to the program, allowing it to classify detected vehicles within the Region of Interest (ROI).

The results highlighted that the YOLOv8 algorithm was suitable for detecting and classifying vehicles in real traffic conditions. In addition, the quantity and quality of datasets significantly influenced the model's performance, particularly its ability to accurately identify vehicle classes and the effectiveness of dataset preprocessing. The performance of the model presented an accuracy score of 94% using the metric mAP@50. This result was obtained by continuously updating the datasets based on the previous performance of the model, hyperparameter tuning was also performed to determine the best algorithm settings in training the model. The model's evaluation indicated a strong relationship between dataset characteristics and the mean Average Precision (mAP) achieved for each class.

Overall, the study serves as a precursor to enhancing the mechanism of traditional traffic lights. It is recommended to partner with a municipal traffic authority to run a pilot at one or two intersections with diverse traffic patterns (peak/off-peak, mixed vehicle classifications, pedestrians); and integrate edge computing to meet the low-latency, reliability, and privacy requirements of an operational traffic-light control system. This innovation has the potential to enhance traffic management efficiency and contribute to the development of smarter and more sustainable urban road systems.

Author Contributions: All authors were actively involved in collecting data and took part in the writing, reviewing, and editing of the manuscript. Each author has read and approved the final version for publication.

Funding: This research received no external funding.
Data Availability Statement: The data supporting this study will be made available upon request by contacting the authors.

Acknowledgments: The researchers would like to thank Cavite State University for its continuous support, which made this research possible. The authors extend their gratitude to the municipality of Dasmariñas and Trece Martires City Traffic Management Office for enabling the researchers to gather information, conduct interviews, and test for this study.

Conflicts of Interest: The researchers declare no conflicts of interest.

REFERENCES

1. Agramon, P.M.G., Lim, M. B. B., Uaje, M. J. B., & Maunahan, H. S. (2024). Proximal surrogate measures for proactive safety evaluation of right-angle vehicle collisions in an intersection. *CMU Journal of Science, 28(1). https://doi.org/10.52751/cmujs.2024.v28i1.tjn2g562*
2. George, R., Vanajakshi, L. D., & Subramanian, S. C. (2019). Area Occupancy-Based Adaptive density Estimation for mixed road traffic. *IEEE Access*, *8*, 5502–5514. https://doi.org/10.1109/access.2019.2962373
3. *Google Colab*. (n.d.). https://colab.research.google.com/drive/1LVKFKYT6TBrYGzG1_hb-sHwyHm8_3gM5?usp=sharing
4. Frande Echaluce, & Macabeo, M. (2024). Evaluation of Traffic Accidents in the Province of Albay: Basis for Sustainable Traffic Management Framework. *JPAIR Multidisciplinary Research*, 55(1), 137–161. https://doi.org/10.7719/jpair.v55i1.487
5. Kumar, M., Kumar, K., & Das, P. (2021). Study on road traffic congestion: A review. *CRC Press eBooks*, 230–240. https://doi.org/10.1201/9781003139883-48
6. Lim, M. B., Lim, H. J., Agramon, P. M., Vitales, G., & Anabo, J. M. (2023). A proposed conceptual framework for the integration of agent-based microsimulation to activity-based demand models. *CMU Journal of Science, 27(2). https://doi.org/10.52751/GQKL6394*
7. Lim, M. B., Lim, H. J., & Rojas, A. W. M. (2022). Bridging the last mile through shared mobility towards an integrated mobility system. *CMU Journal of Science, 26(2). https://doi.org/10.52751/lvpo5704*
8. Ma, M., & Pang, H. (2023). SP-YOLOv5s: an improved YOLOV5 model for remote sensing image tiny object detection. *Applied Sciences, 13*(14), 8615. https://doi.org/10.3390/app13148615
9. Najeeb, S. A., Raza, R. H., Yusuf, A., & Sultan, Z. (2022). Fine-Grained vehicle classification in urban traffic scenes using deep learning. *Lecture notes in electrical engineering* (pp. 902–908). https://doi.org/10.1007/978-981-16-8129-5_138
10. Ngo, H. (2023, June 30). Vehicle-detection-based traffic density estimation at road intersections. *International Journal of Open Information Technologies*. http://injoit.org/index.php/j1/article/view/1554
11. Roboflow. (n.d.). notebooks/notebooks/train-yolov8-object-detection-on-custom-dataset.ipynb at main · roboflow/notebooks. GitHub. https://github.com/roboflow/notebooks/blob/main/notebooks/train-yolov8-object-detection-on-custom-dataset.ipynb
12. Saklani, S., Dhondiyal, S. A., & Singh, D. (2025). Real-Time Traffic Management System using YOLOV8: An analysis of various YOLO models. *4th OPJU International Technology Conference (OTCON) on Smart Computing for Innovation and Advancement in Industry*. 5.0, 1–6. https://doi.org/10.1109/otcon65728.2025.11071056
13. Singh, S., & Santhakumar, S. M. (2021). Empirical analysis of impact of multi-class commercial vehicles on multi-lane highway traffic characteristics under mixed traffic conditions. *Journal of Traffic and Transportation Engineering: English Edition, 11*(3), 545–562. https://doi.org/10.1016/j.jtte.2021.07.005
14. Solawetz, J.. (Sep 4, 2020). Train, Validation, Test Split for Machine Learning. Roboflow Blog: https://blog.roboflow.com/train-test-split/
15. Tas, S., Sari, O., Dalveren, Y., Pazar, S., Kara, A., & Derawi, M. (2022). Deep Learning-Based Vehicle Classification for Low Quality Images. *Sensors*, *22*(13), 4740. https://doi.org/10.3390/s22134740
16. *Traffic Congestion in Metro Manila* (2021, In Congressional Policy and Budget Research Department (No. IF2021-16). https://cpbrd.congress.gov.ph/images/PDF%20Attachments/Factsheets/2021/Factsheet%202021-16-Traffic-congestion-in-metro-manila.pdf
17. Victoria, A. P. C., O. G. D., Biances, J. R. A., & Muhi, M. M. (2018). Analysis of road traffic congestion in selected intersections. *International Journal of Civil Engineering, 1049–1058*.

https://doi.org/10.1007/978-981-97-0751-5_86

CMU Journal of Science
The Official Scientific Journal of Central Mindanao University
ISSN Print: 0116-7847 js.cmu.edu.ph ISSN Online: 2704-3703

Research Article

Effect of rice hull biochar as an additive on the shear strength parameters of silty sand

Ron Gabriel Navarro*, Juliah Cristine Julio, Patrick Adrian Salazar, Andre Cruz, Bien Dave Papasin

1 Department of Civil Engineering, University of the Philippines Los Baños; ronavarro1@up.edu.ph; +639958532932

2 Department of Civil Engineering, University of the Philippines Los Baños; jijulio@up.edu.ph

3 Department of Civil Engineering, University of the Philippines Los Baños; pmsalazar@up.edu.ph

4 Department of Civil Engineering, University of the Philippines Los Baños; accruz4@up.edu.ph

5 Department of Civil Engineering, University of the Philippines Los Baños; bbpapasin@up.edu.ph

Citation: Navarro, R. G., Julio, J. C., Salazar, P. A., Cruz, A., & Papasin, B. D. (2026). Effect of rice hull biochar as an additive on the shear strength parameters of silty sand. CMU Journal of Science, 30(1), 74

Academic Editor: Dr. Ma. Bernadeth Lim

Received: Nov. 25, 2025
Revised: April 22, 2026
Accepted: May 11, 2026
Published: July 2, 2026

Copyright: © 2025 by the authors. Submitted for possible open access publication under the terms and conditions of the Creative Commons Attribution (CC BY) license (https://creativecommons.org/licenses/by/4.0/).

ABSTRACT.

Silty sand is a common soil type in the Philippines. While it exhibits moderate

bearing capacity, its mechanical properties may not be adequate to support heavier structural loads without additional stabilization. This study investigates the use of rice hull biochar as a stabilizer for silty sand. Rice hull biochar is an emerging soil amendment derived from the pyrolysis of agricultural waste, which contains high amounts of silica and has been shown to influence the physical and mechanical behavior of soils. In this study, soil samples were amended with varying percentages of rice hull biochar (0%, 2%, 5%, 8%, 10%, and 12% by weight) combined with 5% cement. Shear strength was assessed under both drained and undrained conditions through direct shear tests and unconsolidated-undrained triaxial tests, respectively. The results revealed that the addition of rice hull biochar improved the cohesion and internal friction angle of the silty sand, contributing to overall enhancement in shear strength. Statistical analysis indicated that a 10% biochar concentration yielded significant improvements to the shear strength parameters compared to the control soil sample. These findings suggest that rice hull biochar, when used with partial cement, can effectively enhance the geotechnical properties of silty sand.

Keywords: silty sand, rice hull biochar, soil stabilization, shear strength

1. INTRODUCTION

Soil is a fundamental component in civil engineering and geotechnical practices, playing a critical role in determining the mechanical properties and overall behavior of structures, including their stability and strength. The behavior of different soil types varies significantly when subjected to structural loads. Based on geotechnical reports from various sites, silty sand is a common soil type found in the Philippines. Silty sand is predominantly a coarse-grained soil, making it suitable as a construction material. However, careful considerations must be taken when dealing with silty sands as foundation material due to the plasticity and impervious nature of silt. In addition, it generally has lower shear strength and load-bearing capacity than clean sands, especially under saturated conditions. Silty sand, a prevalent soil type in the University of the Philippines Los Baños (UPLB), is susceptible to collapse upon contact with water compared to other soil types due to its lower plasticity [1]. Silty sand has good shearing strength when compacted and saturated and fair workability as a construction material [2]. In comparison, clean sand was listed as having an excellent rating for both shear strength and workability. Furthermore, silty sand contains both cohesive and cohesionless soil particles, making it necessary to quantify both its cohesion and friction angle when evaluating its shear strength and overall mechanical behavior.

Soil stabilization is the process of altering soil to enhance its strength, stability, and suitability for construction projects. Different methods of soil stabilization have been developed and are being utilized. These include mechanical stabilization, compaction, drainage improvements, grouting, and chemical stabilization [3]. Mechanical stabilization techniques physically alter the arrangement of soil particles, such as particle-size distribution and void ratio, while chemical stabilization modifies and adjusts the chemical properties of the soil through additives. While effective in improving the strength of soil, chemical stabilization is less common than mechanical stabilization due to the higher costs involved.

Stabilization through the addition of cement and/or ash is a form of chemical stabilization. The hydration of cement acts as a binder for soil particles, thus increasing the strength and stability of the soil [4]. It is effective in improving soils that have low plasticity indices. The calcium oxide present in cement reacts with the natural moisture present in soil, reducing the moisture content of the soil and producing calcium and hydroxyl ions. Silica and alumina present in soils react with the calcium and hydroxyl ions to form calcium-silicate and calcium-aluminate gels through a process called pozzolanic reaction, which increases the stability and stiffness of soil. Cement hydration also occurs, where tricalcium silicates and dicalcium silicates in cement react with water to produce calcium-silicate-hydrate (C-S-H) gels. These also improve the strength and stiffness of the soil. This process can be further improved by additives high in silica or alumina, as it further promotes the pozzolanic reaction.

Cement production accounts for more than 5% of CO2 emissions in the atmosphere, highlighting the need for finding a more environmentally friendly substitute. Materials rich in amorphous silica may be added to the soil-cement mixture to improve the pozzolanic reaction. Biochar has been shown to be a more sustainable substitute for cement in the production of concrete as it is organic and environmentally benign [5]. It is produced through pyrolysis of biomass, which may be in the form of agricultural residues and byproducts [6].

There have been studies that investigated the effects of biochar on the physical and hydraulic properties of soils, particularly in the field of agriculture. It has been shown to improve the water retention as well as improve the wheat yields in clayey soils, while having no significant effect on the hydraulic conductivity [7]. Blanco-Canqui [8] conducted a comprehensive study to evaluate the effects of biochar on various physical and hydraulic soil properties. It was observed that biochar reduces soil bulk density by 3-31%, enhances soil consistency, and decreases saturated hydraulic conductivity in coarse-grained soils while increasing it in fine-grained soils. It was highlighted that the effects of biochar are more pronounced in sandy soils than in clayey soils.

There have also been efforts to explore the effect of biochar on the mechanical properties of soil. Sadasivam and Reddy [9] evaluated the effect of different waste-wood biochar on the compressibility and shear strength of landfill cover soils. It was observed that amending waste-wood biochar to soil increased the compressibility of the soil. However, an

increase in both the cohesion and shear strength of the soil was also noted. This improvement in strength was attributed to the enhanced binding of soil particles, which led to the formation of larger soil aggregates. They further tested the effect of biochar amendment to the slope stability of the soil and obtained higher factors of safety for the biochar amended soils than the soils without amendment. The effect of biochar produced from mesquite, a genus of deep-rooted shrubs and small trees, on the compaction and shear strength of clayey sand was studied [10]. Biochar amendment (5–15% by weight) reduced dry density while increasing cohesion and internal friction angle, likely due to its surface roughness and active functional groups. Undrained shear strength decreased at higher compaction densities but increased at lower ones, showing that initial density strongly influences strength under undrained conditions. Overall, biochar improved shear strength behavior, suggesting potential benefits for bearing capacity improvement and slope stability applications.

Rice hull biochar (RHB) is obtained from the pyrolysis of rice hull. Large production of rice generates a substantial volume of agricultural waste that is underutilized for further uses in the engineering industry, accounting for sustainability considerations. Rice husk biochar has been shown to contain high amounts of SiO2 and thus can be used as a suitable cement replacement in the construction industry [11]. Its viability as a partial cement replacement was studied by observing its effect on the physical, mechanical, microstructural, and radiation shielding properties of ordinary concrete by Mahmoud et al [12]. Results indicated an optimal increase in compressive and tensile strength of concrete at 10% and 15% substitution ratios by cement weight. This shows its effectiveness as a natural pozzolan.

The Philippines is a major rice-producing country. In the Philippines, a total of 2 million metric tons of rice hull waste are being produced annually [13]. This study utilized varying concentrations of RHB (0%, 2%, 5%, 8%, 10%, 12%) and 5% partial cement to improve the strength of silty sand soils. In line with the United Nations Sustainable Development Goals (UN SDGs), this study intends to contribute to the industry, innovation, and infrastructure for sustainable cities and communities. Production of rice hull waste will be allocated efficiently towards sustainable use in the industry.

The objective of this study was to evaluate the effect of RHB on the shear strength parameters of silty sand. Soil samples were prepared with RHB contents of 0%, 2%, 5%, 8%, 10%, and 12% by weight, each combined with a fixed 5% cement content. The shear strength parameters were obtained through direct shear and triaxial tests. In addition, the study aimed to assess the significance of the observed differences and determine the optimal RHB content through statistical analyses.

METHODOLOGY

2.1 Material Procurement and Characterization

Rice hull biochar was produced through the pyrolysis of rice hull. The procured RHB is shown in Figure 1.



Figure 1. Procured RHB

The RHB was subjected to X-ray fluorescence (XRF) analysis. This is a non-destructive method used to identify and quantify the elemental composition of materials. In this technique, samples are irradiated by high-energy primary X-rays, causing atoms in the samples to emit secondary X-rays. The energies of these emissions are measured to identify and quantify the elements present in the samples [14]. The results indicate that the inorganic fraction of the sample is mainly composed of amorphous silica. It must be noted that XRF analysis cannot quantify light elements such as carbon. The concentrations are shown in Table 1.

Table 1. Composition of RHB

Chemical Composition	Concentration (excluding carbon)
SiO_2	96.89%
K	2.39%
Ca	0.40%
Other chemical compounds	0.32%

The soil used for the study was obtained near the New Dormitory Residence Hall within the UPLB. It was subjected to index tests, including particle-size analysis, Atterberg limits tests, and the compaction test in accordance with ASTM standards to determine the soil classification and the optimum moisture content.

Sieve analysis was conducted following ASTM D6913 [15]. Figure 2 shows the particle-size distribution curve. The soil contains 5.12% gravel, 79.60% sand, and 15.28% fine soil particles, indicating a sandy soil with a significant amount of fine soil.

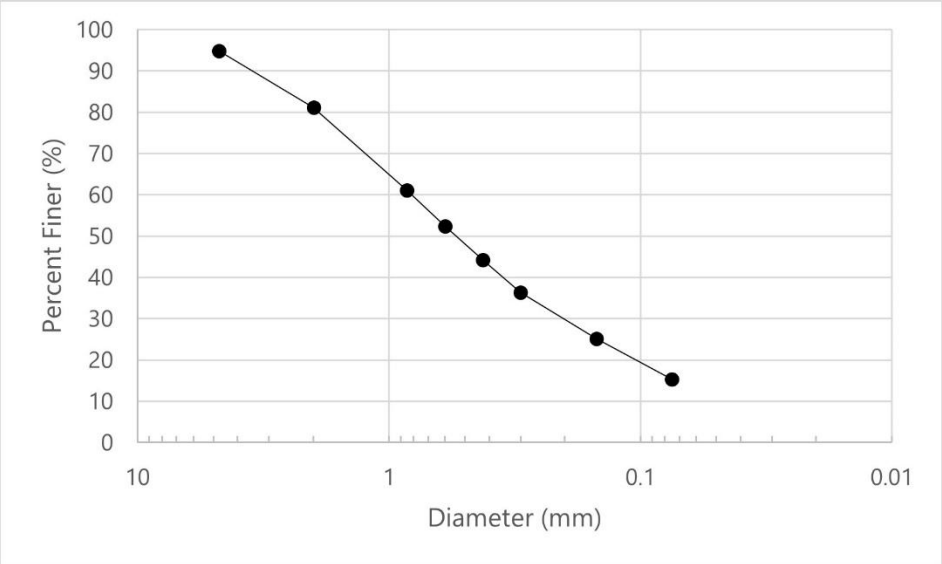


Figure 2. Particle-Size Distribution Curve of Soil

Atterberg limits tests were conducted following ASTM D4318 [16] to determine the liquid limit and the plastic limit. The plasticity index was calculated as the difference between the liquid and plastic limits. Table 2 shows the results of the Atterberg limits test, indicating that the fine particles of the soil are silty in nature.

Table 2. Consistency of procured soil.

Liquid Limit	Plastic Limit	Plasticity Index	A-line Plasticity Index
33.19%	29.50%	3.69%	9.63%

Following ASTM D2487 [17], the soil is classified as silty sand. Lastly, the standard proctor test showed that the soil had an optimum moisture content of 18.24%

Portland Cement Type I with a specific gravity of 3.1 was used, and a constant percentage of 5% was incorporated for every setup in the experiment.

The direct shear testing machine used in the study is the "DIGISHEAR", a product of CONTROLS, an Italian manufacturer of materials and testing instruments. For triaxial testing, the "TRIAX" Triaxial Load Frame, which is also a product of CONTROLS, was utilized.

2.2 Specimen Preparation

Water equivalent to 18.24% of the weight of the soil was added to simulate the optimum moisture content. The soil was then mixed with 0%, 2%, 5%, 8%, 10%, and 12% RHB, along with the 5% partial cement, based on the dry weight of the soil. For the direct shear test, this mixture was transferred and compacted in shear box molds with a size of 60 mm by 60 mm by 20 mm. Ninety samples were prepared for the direct shear test, corresponding to six concentrations, three applied normal loads, and five trials per set. These were allowed to be cured for 28 days.

For the triaxial test, the mixture was transferred and compacted in a cylindrical mode with a size of 36 mm by 78 mm. Similarly, ninety samples were prepared for the direct shear test corresponding to six concentrations, three confining pressures, and five trials per set. However, only one mold was available for the triaxial test. After compaction, they were extracted before being allowed to cure for 28 days. Table 3 shows the experimental design while Figure 3 shows the prepared specimens being cured for direct shear and triaxial testing.

Table 3. Summary of experimental design

Test	RHB Concentration (%)	Cement Concentration (%)	Stress Variable	Stress Levels (kPa)	Trials	Total Samples
Direct Shear Test	0, 2, 5, 8, 10, 12	5	Normal Stress	27.25, 54.50, 81.75	5	90
Triaxial Test	0, 2, 5, 8, 10, 12	5	Confining Pressure	98, 196, 392	5	90



Figure 3. Prepared specimens being cured for direct shear and triaxial test.

2.3 Direct Shear Test

Direct shear tests were conducted in accordance with ASTM D3080-23 [18]. Normal loads of 10, 20, and 30 kg were applied on the soil samples, equivalent to normal stresses of 27.25 kPa, 54.50 kPa, and 81.75 kPa. A constant shear displacement rate of 1.00 mm/min was applied to the samples. The test was stopped once the proving ring reading reached a maximum value and began to decrease, indicating failure of the soil specimen. The shear stress at failure was obtained by multiplying the proving ring reading by a calibrated conversion factor of 2 N/mm.

The shear stress at failure was plotted against the normal stress and a best-fit line was obtained for each trial. Following the Mohr-Coulomb failure criterion, the y-intercept of the line represents the cohesion of the soil while the inverse tangent of the

slope of the line represents the friction angle of the soil. This is shown by Eq. (1)

$$\tau_f = c + \sigma \cdot tan(\phi) \quad (1)$$

Where:

τ_f is the shear stress at failure

c is the cohesion of the soil

σ is the normal stress acting on the shearing plane

ϕ is the friction angle of the soil

2.4 Triaxial Test

Triaxial tests were conducted in accordance with ASTM D2850-23 [19]. To simulate the optimum moisture condition of the soil, the saturation stage was not conducted, and the soil was tested under unsaturated conditions, leading to both cohesion and friction angle being measured by the test. Confining pressures of 98 kPa, 196 kPa, and 392 kPa were applied and the deviator stress was increased until the soil specimen failed. The corresponding Mohr's circles at failure were plotted, and a line tangent to the circles represented the Mohr-Coulomb failure criterion of the soil. Similarly, the cohesion and friction angle were obtained from these lines following Eq. (1).

2.5 Statistical Analysis

One-way Analysis of Variance (ANOVA) was conducted to evaluate whether the results from different concentrations showed significant differences in both the direct shear test and the triaxial test. Statistical significance was set at $p < 0.05$. If the ANOVA indicated significance, a post hoc Tukey's Honestly Significant Difference (HSD) Test was performed to identify the specific group pairs that differed, using the same threshold $p < 0.05$.

RESULTS AND DISCUSSION

3.1 Direct Shear Test Results

Table 4 presents the average shear stress values corresponding to varying concentrations of rice hull biochar at three levels of normal stress: 27.25 kPa, 54.50 kPa, and 81.75 kPa. Figure 4 shows the mean cohesion for each concentration while Figure 5 shows the mean friction angle for each concentration. Standard errors are also shown. For comparison, the friction angle and cohesion of silts and sands range from 26° to 38°, depending on the soil density [20]. In the specimen preparation, the samples were naturally densified by a tamping apparatus, leading to higher values of the friction angle. Furthermore, while cohesion of untreated coarse-grained soils is typically low and ranges from 0kPa to 10kPa, the inclusion of 5% cement introduced cementitious bonding. This modification created an artificial cohesion within the soil-RHB matrix, leading to the higher strength values observed in this study.

Table 4. Average shear stress at failure (kPa) obtained from the direct shear test.

Concentration of RHB	Shear Stress (kPa)		
	$\sigma = 27.25\ kPa$	$\sigma = 54.50\ kPa$	$\sigma = 81.75\ kPa$
0%	27.78	42.11	61.78
2%	30.33	52.56	69.78
5%	31.67	55.44	73.89
8%	35.56	59.89	75.67
10%	40.44	63.78	77.33
12%	42.44	58.67	73.11

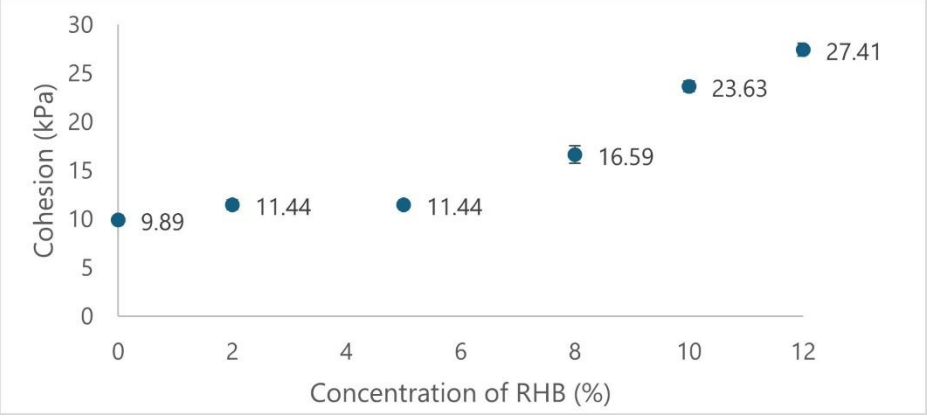


Figure 4. Cohesion obtained from direct shear test for each concentration of RHB

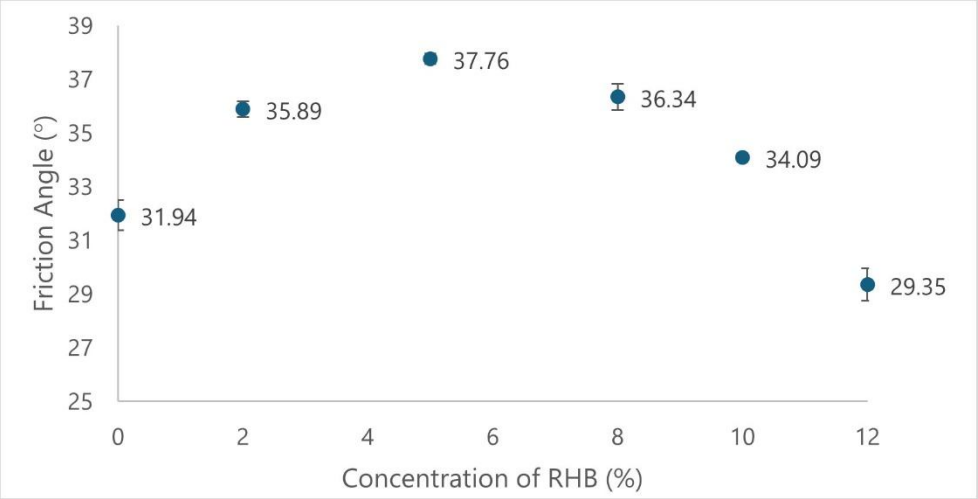


Figure 5. Friction angle obtained from the direct shear test for each concentration of RHB

The results indicate that as the concentration of rice hull biochar increases, the average shear stress generally shows an increasing trend across all normal stress levels, suggesting improved soil resistance to shear forces. Specifically, for the lowest normal stress (27.25 kPa), the average shear stress ranges from 27.78 kPa at 0% biochar concentration to 42.44 kPa at 12% concentration. Similarly, at 54.50 kPa and 81.75 kPa normal stresses, the average shear stress increases from 42.11 kPa to 58.67 kPa and from 61.78 kPa to 73.11 kPa, respectively, as the biochar concentration rises.

There is an increasing trend observed for cohesion, from 9.89 kPa to 27.41 kPa as the concentration of RHB increases. This implies that the addition of RHB causes an observable improvement to the cohesion of the soil. The friction angle increased from 31.94° to 37.76° at 5% concentration but decreased to 29.35° at 12% concentration. This result slightly contrasts with the findings of Hussain et al. [10], where the friction angle continued to increase up to a 15% amendment of biochar derived from mesquite. The difference in results may be attributed to the physical difference between mesquite and rice husk biochar. Hussain et al attributed the increase in friction angle to the roughness present in the surface of the mesquite biochar. Mesquite, a hardwood derivative, has higher robustness and rigidness than rice husk. It is expected that biochar derived from mesquite exhibits higher surface roughness and friction than biochar derived from rice husk. In Sadasivam and Reddy [9], both cohesion and friction angle increased between 0% and 10% amendment of wood-derived biochar in soil. A similar effect was observed in the present study for the amendment of RHB to silty sand.

ANOVA shows significant differences for the direct shear test results, both for cohesion and friction angle. Cohesion exhibited a generally increasing trend with increasing biochar content, suggesting that the addition of RHB enhanced the apparent bonding between soil particles, possibly due to improved cementation process. On the other hand, the friction angle initially increased with RHB concentration, indicating better interparticle interaction and resistance to sliding. This can be attributed to a larger effective particle size after cementation of the soil particles. However, a decrease in higher

concentrations was observed. This behavior may be attributed to the excess biochar particles interfering with particle interlock or contributing to a more lubricated interface, which could reduce frictional resistance at higher contents.

Tukey's HSD test was performed for both cohesion and friction angle. Significant differences were observed between cohesions obtained at different concentrations for all pairs except those between 0% and 2%, 0% and 5%, and 2% and 5%. Meanwhile, significant differences in friction angles were observed between pairs at different concentrations, except for 2% and 8%, 2% and 10%, and 5% and 8%.

3.2 Triaxial Test Results

Table 5 presents the average shear stress values corresponding to varying concentrations of rice hull biochar at three levels of confining pressure: 98 kPa, 196 kPa, and 392 kPa. Figure 6 shows the mean cohesion for each concentration while Figure 7 shows the mean friction angle for each concentration. Standard errors are also shown.

Table 5. Average shear stress at failure (kPa) obtained from triaxial test.

Concentration of RHB	Shear Stress (kPa)		
	$\sigma_1 = 98\ kPa$	$\sigma_1 = 196\ kPa$	$\sigma_1 = 392\ kPa$
0%	466.04	674.86	940.99
2%	467.23	760.00	971.81
5%	514.57	753.97	1008.61
8%	526.51	831.86	1128.40
10%	558.94	798.81	1205.37
12%	554.10	861.30	1253.66

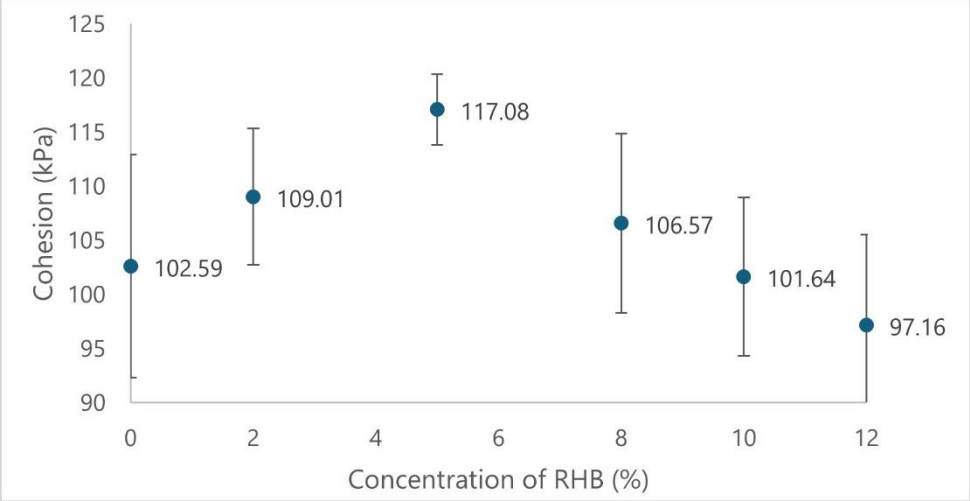


Figure 6. Cohesion obtained from triaxial test for each concentration of RHB

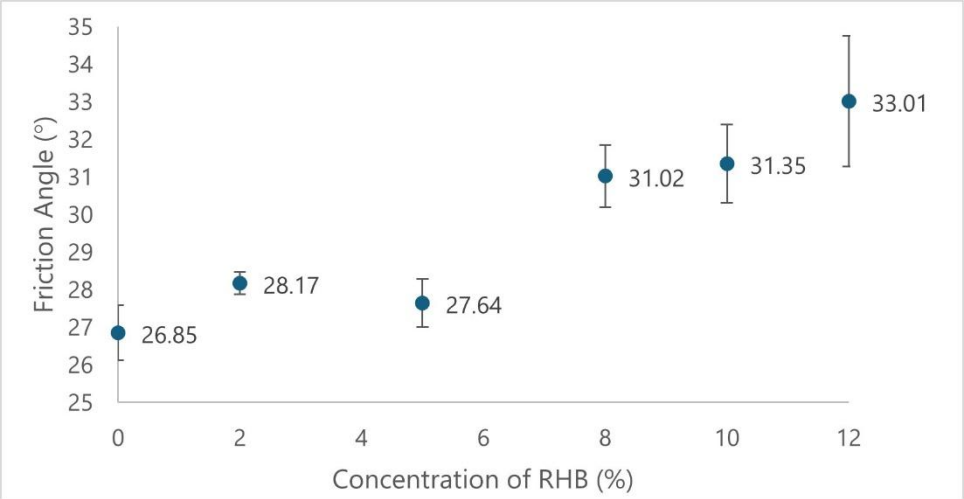


Figure 7. Friction angle obtained from triaxial for each concentration of RHB

An increasing trend was observed for the deviator stress as rice hull biochar content increases. Cohesion increased from 102.59 kPa to 117.07 kPa at 5% concentration, then decreased to 97.16 kPa at 12% concentration. Significantly higher values of cohesion are observed in this test than in the direct shear test due to the undrained conditions of the test. However, friction angles were measured by the test, which is usually not the case for unconsolidated-undrained triaxial tests. This is attributed to the specimens not being fully saturated before testing in an effort to maintain the target optimum moisture content. The friction angle generally increased from 26.85° at 0% concentration to 33.01° at 12% concentration. This aligns with the results obtained in previous research on shear strength of biochar-amended soils [9, 10].

Significant differences were not observed for the cohesion obtained from the undrained triaxial test. Figure 6 shows large standard errors, indicating high variability of results. The observed inconsistency may again be attributed to unsaturated conditions during testing. The different concentrations of RHB may have absorbed varying amounts of water for reaction, resulting in uneven pore pressure conditions during the tests. In contrast, the results still showed a statistically significant difference for the friction angle. This is because the test was interpreted using total stress parameters, and despite the absence of pore pressure control, the trend in shear strength remained consistent across all confining pressures. As the RHB concentration increased, the total shear strength also increased, which led to a noticeable increase in the apparent friction angle. Since the changes were consistent and less variable compared to cohesion, the difference in friction angle with increasing biochar content was found to be statistically significant. Tukey's Honestly Significance Difference test further shows that significant differences were observed between 0% and 10%, 0% and 12%, 2% and 12%, and 5% and 12%.

CONCLUSION

Rice hull biochar was able to improve the shear strength of soil. Based on direct shear test results, cohesion was increased from 9.89 kPa at 0% concentration to 27.41 kPa at 12% concentration. A peak friction angle of 37.76° was observed at 5% concentration compared to 31.94° at 0% concentration. Direct shear test showed good reliability, as supported by the significant differences reported by statistical analysis. In contrast, the triaxial test results were more uncertain, likely due to the unsaturated conditions of the samples during testing and possible changes in the moisture content after the cementation process. The highest cohesion was observed at 5% concentration with a value of 117.08 kPa; however, no significant difference was observed between the different concentrations. The friction angle, on the other hand, significantly increased from 26.85° at 0% concentration to 33.01° at 12% concentration.

Based on the results of the statistical analysis, an optimum concentration of 10% RHB is recommended, as significant increases in all shear strength parameters are observed when compared to the control sample. Increasing further to 12% may decrease or have no significant effect on the friction angle. This suggests the need for dosage control. The increase in shear strength parameters can be attributed to the high amorphous silica content of the RHB, which promotes the pozzolanic reaction with the

cement and enhances the cementation of soil particles. This leads to both higher cohesion and friction angle; cohesion is directly related to the cementation, while the increase in friction angle may be attributed to the increase in the effective particle size of the soil particles after binding.

Rice hull biochar shows promise as an environmentally friendly stabilizer for silty sand, especially in areas where rice by-products are readily available. To build on these results, future work should examine how RHB-treated soils behave over time under different moisture levels and loading conditions, while also considering the role of curing and compaction practices. Field-scale trials are also encouraged to confirm the laboratory outcomes and to better understand the cost-effectiveness and sustainability of using RHB in real geotechnical projects.

Author Contributions: Conceptualization, R.G.O.N.; Data collection and analysis, J.C.I.J. and P.A.M.S.; Data analysis review, R.G.O.N., A.C.C., and B.D.B.P.; Manuscript drafting, R.G.O.N., J.C.I.J., and P.A.M.S.; Manuscript review, A.C.C. and B.D.B.P. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding

Data Availability Statement: The datasets generated and analyzed during the study are available from the corresponding author upon reasonable request.

Acknowledgments: We would like to acknowledge the laboratory technicians of the Department of Civil Engineering, Alexander M. Marinas Jr. and Ernesto G. Gopela, for their tireless assistance in the operations of the shear testing equipment.

Conflicts of Interest: The authors declare no conflicts of interest.

REFERENCES

1. Abbasi, N.; Mahdieh, M. Improvement of geotechnical properties of silty sand soils using natural pozzolan and lime. *International Journal of Geo-Engineering*. 2018. 9:4. https://doi.org/10.1186/s40703-018-0072-4

2. Budhu, M. *Soil Mechanics and Foundations*, 3rd ed.; John Wiley & Sons, Inc.: Hoboken, New Jersey, USA, 2011.

3. Bowles, J.E. *Foundation Analysis and Design*, 3rd ed.; McGraw-Hill International Edition: Singapore , 1997.

4. Han, J. *Principles and Practices of Ground Improvement*.; John Wiley & Sons, Inc.: Hoboken, New Jersey, USA, 2015

5. Singhal, S. Biochar as a cost-effective and eco-friendly substitute for binder in concrete: a review. European *Journal of Environmental and Civil Engineering*. 2022. 27(2):984–1009. https://doi.org/10.1080/19648189.2022.2068658

6. Barbhuiya, S.; Das, B.B.; Kanavaris, F. Biochar-concrete: a comprehensive review of properties, production and sustainability. *Case Studies in Construction Materials*. 2024. 20:e02859. https://doi.org/10.1016/j.cscm.2024.e02859

7. Castellini, M.; Giglio, L.; Niedda, M.; Palumbo, A.D.; Ventrella, D. Impact of biochar addition on the physical and hydraulic properties of a clay soil. *Soil and Tillage Research*. 2015. 154:1–13. https://doi.org/10.1016/j.still.2015.06.016

8. Blanco-Canqui H. Biochar and soil physical properties. *Soil Science Society of America Journal*. 2017. 81(4):687–711. https://doi.org/10.2136/sssaj2017.01.0017

9. Sadasivam, B.Y.; Reddy, K.R. Engineering properties of waste wood-derived biochars and biochar-amended soils. *International Journal of Geotechnical Engineering*. 2015. 9(5):521–535. https://doi.org/10.1179/1939787915Y.0000000004

10. Hussain, R.; Ghosh, K.K.; Garg, A.; Ravi, K. Effect of biochar produced from mesquite on the compaction characteristics and shear strength of a clayey sand. *Geotechnical and Geological Engineering*. 2020. 39:1117–1131. https://doi.org/10.1007/s10706-020-01549-2

11. Morales, L.F; Herrera, K.; Lopez, J.E.; Saldarriaga, J.F. Use of biochar from rice husk pyrolysis: assessment of reactivity in lime pastes. *Heliyon*. 2021. 7(11):e08423. https://doi.org/10.1016/j.heliyon.2021.e08423

12. Mahmoud, A.A.; El-Sayed, A.A.; Fathy, I.N.; Fawzy, S.; Alturki, M.; Elfakharany, M.E.; Abouelnour, M.A.; Mahmoud, K.A.; Dahish, H.A.; ElTalawy, S.M.; et al. Evaluation of rice husk biochar influence as a partial cement replacement material on the

physical, mechanical, microstructural, and radiation shielding properties of ordinary concrete. *Scientific Reports*. 2025.15:27229. https://doi.org/10.1038/s41598-025-11987-8

13. PhilRice (Philippine Rice Research Institute). Rice husks as sustainable energy resource. 2016. Available online: https://www.philrice.gov.ph/ (accessed on 13 August 2025).

14. Leng, Y. *Materials Characterization: Introduction to Microscopic and Spectroscopic Methods*; John Wiley & Sons (Asia) Pte Ltd.: Singapore, Singapore, 2008.

15. ASTM International. ASTM D6913/D6913M-17: Standard Test Methods for Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis. ASTM International: West Conshohocken, Pennsylvania, USA, 2017.

16. ASTM International. ASTM D4318-17: Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils. ASTM International: West Conshohocken, Pennsylvania, USA, 2017.

17. ASTM International. ASTM D2487-17: Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System). ASTM International: West Conshohocken, Pennsylvania, USA, 2017.

18. ASTM International. ASTM D3080/D3080M-22: Standard test method for direct shear test of soils under consolidated drained conditions. ASTM International: West Conshohocken, Pennsylvania, USA, 2023.

1. ASTM International. ASTM D2850-23: Standard test method for unconsolidated-undrained triaxial compression test on cohesive soils. ASTM International: West Conshohocken, Pennsylvania, USA, 2023.

2. Das, B.M.; Sobhan, K. *Principles of Geotechnical Engineering*, 9th ed.; Cengage Learning: Boston, MA, USA, 2016.

Disclaimer/Publisher's Note: The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of CMUJS and/or the editor(s). CMUJS and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.

CMU Journal of Science
The Official Scientific Journal of Central Mindanao University
ISSN Print: 0116-7847 js.cmu.edu.ph ISSN Online: 2704-3703

Research Article

The Removal of Ethics from Higher Education: A Critical Threat to the Philippine Educational System

Givheart C. Dano[1]

1 Faculty of Political Science, Institute of Arts and Sciences, Tangub City Global College, Tangub City, Philippines

Email: givheart.dano6151998@yahoo.com

Citation: Dano, G.C. (2026). The Removal of Ethics from Higher Education: A Critical Threat to the Philippine Educational System. CMU Journal of Science, 30(1), 85

Academic Editor: Dennis Relojo-Howell, MSc, MBPsS

Received: Dec 11, 2025
Revised: Feb 01, 2026
Accepted: May 12, 2026
Published: July 2, 2026

Copyright: © 2024 by the authors. Submitted for possible open access publication under the terms and conditions of the Creative Commons Attribution (CC BY) license (https://creativecommons.org/licenses/by/4.0/).

ABSTRACT.

In this paper, I argue that the policy recommendation by the Commission on Higher Education (CHED) and the Department of Education (DepEd) to remove ethics courses from the higher education curriculum in the Philippine education system poses a serious threat. This policy proposal will only worsen existing problems; it will neither resolve them nor advance the true goals of education, whose fundamental task is to liberate, not to enslave. Using a qualitative approach through content analysis, this paper puts forward two main arguments. First, the policy recommendation to remove ethics courses by CHED, DepEd, and other educational bodies is policy-defective; it fails to address the country's existing educational problems and may even worsen them, such as by further weakening critical thinking. Second, removing ethics courses will reduce education in the country to a purely commercial pursuit, stripping it of its formative and humanistic functions. As part of the general education curriculum in higher education, ethics is the only subject that explicitly teaches students to engage with complex social issues through informed moral decision-making. In support of this view, the paper echoes Aristotle's assertion: "Educating the mind without educating the heart is no education at all."

Keywords: Commission on Higher Education, Curriculum, Education, Ethics, Policy

INTRODUCTION

Recently, on May 28, 2025, the academic community in the country was shocked by the policy proposal, supported by Commission on Higher Education (CHED) and the Department of Education (DepEd), to remove three (3) general education (GE) subjects from the college curriculum (Panti, 2025). What is more striking about the news is that, among the general education (GE) courses, Ethics was included in the subjects proposed for removal and transfer to basic education. Most of those who reacted to this are philosophers and other individuals who teach Ethics in higher education institutions in the country. However, according to DepEd Assistant Secretary Janir Datukan, who spoke during a hearing of the House Committee on Basic Education and Culture on the revised Senior High School (SHS) curriculum, the reason DepEd endorsed such a policy is due to the perceived redundancy of the subject. "We have five [subjects]...meaning 15 units out of the 50 existing units of General Education, which are already integrated in senior high school [curriculum]. That 15 units will increase with these three courses [which is three units each]: art appreciation, contemporary world and ethics" (Panti, 2025).

DepEd also claimed that Ethics can be placed in the same category as the basic-education subject *Good Manners and Right Conduct and Values Education* (GMRC-VE). This claim, however, has been debunked by a group of philosophy scholars, who argue that Ethics and GMRC-VE are not, and will never be, the same (UPLB Official Statement, 2025). Ethics is a field that investigates the philosophical foundations of moral judgment, making it fundamentally distinct from GMRC-VE's prescriptive approach to morality. GMRC-VE, established under Republic Act 11476 (the GMRC and Values Education Act), rests on the premise that society already shares a set of basic moral values and etiquette. Because the law starts from this assumption, GMRC-VE is not designed to promote critical discourse on why and how we hold particular moral beliefs. Only through the study of Ethics are students exposed to diverse frameworks for critically analyzing and evaluating what is good and right, and thus challenged to examine the grounds and scope of their own moral agency. These concerns are philosophical in nature and therefore belong within a philosophy course (UPLB Official Statement, 2025).

As a matter of perspective, Imbong (2025) argued that DepEd's policy proposal to remove Ethics and other General Education (GE) courses from higher education is intellectually flawed, constitutionally unsound, and democratically dangerous. He defends Ethics as essential not only for personal moral development but also for sustaining a critically engaged, democratic society.

Maboloc (2025) argues that the proposal to remove the Ethics course from the General Education curriculum in college is a clear manifestation of the commercial and neoliberal direction of Philippine education. He describes this move as "existential suicide," not only because it disregards the intellectual and civic importance of Ethics, but also because it reflects the growing commodification of education where labor, particularly that of teachers, is sacrificed for administrative efficiency and cost-saving. More critically, Maboloc (2025), asserts that transferring Ethics to Senior High School undermines its role as a professional and formative discipline suited for cognitively mature college students. Ethics, for Maboloc, is essential in cultivating civic responsibility, critical thinking, and the moral discernment necessary in a democratic society. Maboloc (2025) warns that without Ethics, students are deprived of the ability to understand the value of human freedom and moral autonomy.

Building on the arguments presented above, this paper argues, without bias, that the policy recommendation by the Commission on Higher Education (CHED) and the Department of Education (DepEd) to remove Ethics courses from the higher education curriculum in the Philippine education system poses a serious threat. To advance this claim, the paper presents two central arguments regarding the removal of the Ethics course from college education. First, the recommendation by CHED and other educational policy-making bodies is policy-defective; it fails to address the country's pressing educational challenges and may exacerbate existing problems, such as the lack of critical thinking skills. Second, removing the Ethics courses will reduce education in the country to a purely commercial pursuit, stripping it of its formative and humanistic values.

To support this argument, the paper is organized into the following sections. First, it presents the background of the college curriculum, specifically the role and relevance of general education courses in contemporary society. Second, it examines the challenges faced by Philippine education, particularly concerning the development of critical thinking and the influence of market-driven tendencies. Finally, the paper argues that the proposed removal of the Ethics course from the college curriculum is policy-defective, as it undermines critical thinking and reduces education to a mere commercial pursuit.

LITERATURE REVIEW

Education is not just about acquiring information and technical skills. Technical skills or 'hard skills' is often associated with the use of tools, equipment related to work properly and efficiently (Medina, 2010). For Verma (2024), education is also empowering individuals, shaping the character, and civic responsibility of individuals within a society. Ethics, as a subject, embodies this formative function.

Since then, Greek philosopher Aristotle (384-322 BC) provides one of the earliest philosophical arguments of education as moral cultivation. In his seminal work *Nicomachean Ethics*, he argues that the ultimate goal of education is not simply intellectual achievement but the development of virtue (*aretê*) and practical wisdom (*phronesis*) (Harðarson, 2019). For Aristotle, human flourishing (*eudaimonia*) is attainable only through the habitual practice of moral reasoning guided by ethical principles (Symons & VanderWeele, 2024). As a matter of perspective, American philosopher John Dewey (1859 - 1952), writing in the early 20th century, opined a similar argument within the context of democratic societies. In his work *Democracy and Education* (1916), Dewey argues that education should not be an instrument of passive social reproduction but a dynamic, participatory process through which learners engage with real-world problems. Ethical inquiry, for Dewey, is not a peripheral activity; it is central to promoting the kind of critical thinking and public deliberation that democratic life demands (Williams, 2017).

On a more radical side, Brazilian philosopher Paulo Freire (1921-1997) in his seminal work *Pedagogy of the Oppressed* (1970), offers a more radical critique. For Freire, education is either a practice of freedom or a practice of domination. In other words, education empowers learners toward liberation and critical consciousness, or enforces conformity, sustaining oppressive systems and limiting human potential. Further, American philosopher Nel Noddings (1929-2022), with her *ethics of care*, adds a relational and affective dimension to moral education. For Noddings (1984), ethical learning must be grounded in empathy, responsibility, and attentiveness to the needs of others. In an educational system increasingly dominated by metrics and market logic, Noddings reminds us that ethical life is lived in connection with others (Tan, 2022).

However, in contemporary society, education is gradually being challenged by the rise of neoliberalism. At its core, neoliberalism emphasizes the efficiency of markets in allocating resources, individual responsibility, entrepreneurial freedom, and competition as the primary mechanisms for human progress (Saad-Filho&Johnston, 2005). It argues that the role of the state should be reduced to maintaining the rule of law, enforcing private property rights, and ensuring the functioning of free markets (Friedman, 1962). In other words, public goods and services, such as education, health care, and social welfare, are increasingly treated as commodities subject to market logic. Under neoliberalism, the primary purpose of education is redefined: rather than being a means for holistic human development and civic empowerment, it becomes narrowly focused on producing individuals with market-relevant skills (Giroux, 2014). This ideological shift reshapes the curriculum to emphasize technical competencies, job readiness, and productivity, often at the expense of critical thinking, ethical reasoning, and democratic engagement (Balan, 2023; Edeji, 2024).

It can be argued that neoliberalism really poses a threat to critical thinking and the preservation of shared human values by transforming education into a market-driven enterprise focused on economic utility. Harvey (2005) argued this framework marginalizes essential aspects of learning, particularly the development of critical, ethical, and civic reasoning, which are difficult to measure, commodify, or monetize. Moreover, the neoliberal emphasis on individual success undermines the collective pursuit of the common good. Giroux (2014) argues that neoliberal education promotes a consumerist mindset that detaches individuals from a sense of social responsibility and empathy. In such a phenomenon, students are conditioned to prioritize personal gain and employability over justice, equity, and civic engagement. As a result, democratic participation weakens, and the space for moral deliberation contracts, making societies more vulnerable to authoritarianism, misinformation, and moral apathy (Desierto & de Maio, 2020; Mutuota, 2024).

Being silent on this matter will silence the very voice that defends the voiceless, what Maboloc (2025) calls an "existential suicide." This silence undermines the essence of a democratic society. As Freire (1970) argued, education must be a practice of freedom, not conformity. By surrendering education to market imperatives, we risk raising generations who are technically skilled but morally directionless. This paper aims to argue that the policy proposal by the Commission on Higher Education (CHED) and the Department of Education (DepEd) to remove Ethics courses from the higher education curriculum in the Philippine education system poses a serious threat.

METHODOLOGY

This paper used qualitative content analysis to critically examine relevant text and official memoranda related to the proposed removal of the Ethics course from the higher education curriculum in the Philippines. Content analysis, as defined by Krippendorff (2018), is a systematic method for interpreting textual material by identifying patterns, themes, and meanings embedded within documents. This approach allows the researcher to assess not only the surface-level content but also the underlying ideologies, assumptions, and implications of policy discourse (McLeod, 2024)

No human participants were involved, and all data are publicly accessible documents and publications. Thus, the paper did not require ethical clearance. However, the research followed academic integrity protocols, including proper citation, interpretive rigor, and critical engagement with sources. By using content analysis, the paper aims to reveal how the removal of Ethics courses reflects broader ideological shifts, particularly the rise of neoliberal and market-driven priorities in higher education, which risk reducing education to mere commercial pursuit at the expense of humanistic and civic formation.

RESULTS AND DISCUSSION

General Education Courses in Higher Education Curriculum Role and Relevance

Technically speaking, General Education (GE) courses are a component of the higher education curriculum that is shared by all undergraduate students, regardless of their chosen field of study. This is in accordance with the Commission on Higher Education's (CHED) reform efforts and paradigm shift to strengthen the Philippine educational system, as outlined in CHED Memorandum Order No. ___, Series of 2013. As mandated by the 1987 Philippine Constitution, the State "shall protect and promote the right of all citizens to quality education at all levels" (Article XIV, Section 1); "establish, maintain, and support a complete, adequate, and integrated system of education relevant to the needs of the people and society" (Article XIV, Section 2); and "exercise reasonable supervision and regulation of all educational institutions." These constitutional mandates are further reinforced by Republic Act No. 7722, otherwise known as the "Higher Education Act of 1994," which empowers CHED to "set minimum standards for programs and institutions of higher learning" (Section 8d).

General Education courses introduce learners to diverse areas of knowledge and approaches to understanding both social and natural realities (Laird, Niskodé-Dossett, & Kuh, 2009). Through these GE courses, students are expected to develop key intellectual skills: such as critical, analytical, and creative thinking as well as various modes of communication. Moreover, it aims to cultivate civic abilities essential for active participation in the local, national, and global community (CHED Memo., 2013).

The debate over the role of General Education (GE) in higher education is not limited to the Philippines, it reflects a global tension between two competing educational paradigms: the humanistic approach and the neoliberal approach. According to Lei (2007), the humanistic approach argues for the development of the whole person, recognizing that effective learning must consider not just intellectual growth, but emotional and psychological well-being. On the other hand, neoliberal approach in education refers to the application of market-based principles to the organization and goals of educational systems. Rooted in economic theories, this philosophy transforms schools and universities into service providers and students into consumers (Davies & Bansel, 2007).

In the United States, the Association of American Colleges and Universities (AAC&U) champions a liberal education framework, arguing that GE courses are essential for cultivating analytical reasoning, ethical judgment, and intercultural competence (AAC&U, 2015). Prestigious institutions such as Harvard and Stanford uphold this philosophy by requiring students to complete core subjects in the humanities, natural sciences, and ethics. These are not peripheral subjects, they serve to anchor specialized knowledge in broader societal, moral, and civic contexts (Delbanco, 2012). In contrast, Finland offers a more integrated and value-driven alternative. Its globally admired system blends academic rigor with ethical and civic formation, embedding GE principles such as democratic participation and well-being throughout all educational levels (Sahlberg, 2015). This approach proves that a strong GE curriculum is not only compatible with excellence but essential to producing reflective and socially responsible citizens.

It is clear that General Education (GE) occupies a foundational role in the architecture of higher education. It serves as the formative core of college learning, equipping students not just with discipline-specific knowledge but with broader intellectual and civic capacities. In the Philippine context, this educational vision was concretely institutionalized through CHED Memorandum Order (CMO) No. 20, Series of 2013, which outlines the revised General Education Curriculum (GEC). The CMO frames GE as "holistic education that empowers

learners as active participants in the development of society" (CHED, 2013, p. 2). The GE program is meant to develop the Filipino learner into a "makatao, makabayan, makakalikasan, and makadiyos" citizen, anchored in humanistic, ethical, and democratic values.

This vision reflects global best practices where general education is tasked not only with the transmission of knowledge but with the cultivation of skills and dispositions necessary for ethical reasoning, critical thinking, intercultural understanding, and responsible citizenship (Delbanco, 2012). GE courses such as Ethics, Contemporary World, and other Social Sciences are indispensable in enabling students to reflect on fundamental human concerns, justice, truth, dignity, freedom, and how these values manifest in contemporary social and political contexts. These courses resist the narrowing of education into technocratic aspects, arguing instead that education must aim for human formation and social transformation (Nussbaum, 2010). It can be argued then, that the implementation of CMO No. 20, s. 2013 signaled a deliberate shift away from an overloaded, discipline-heavy curriculum toward a leaner but deeper general education framework. The revised GEC consists of 36 units of core and elective courses designed to promote interdisciplinary thinking, moral integrity, and intellectual autonomy. Among these, Ethics is listed as one of the core courses, emphasizing its role in forming the student's capacity for moral discernment and civic responsibility. The inclusion of Ethics is neither accidental nor optional, it is based on the premise that Filipino students must not only learn how to work, but how to live well and relate ethically with others in a rapidly changing society (CHED Memo., 2013).

In that regard, general education is the moral and intellectual heart of higher education. It enables students to go beyond specialization and see the bigger picture of human life and society. The Ethics course, in particular, plays a vital role in shaping future leaders, professionals, and citizens who are capable not just of competence, but of conscience. CHED's commitment to GE through CMO No. 20, s. 2013 must be reaffirmed, not reversed. The removal of GE courses from higher education would be a tragic step backward, undermining the very goals of education in a democratic society.

Critical Thinking and the Influence of Market-Driven Tendencies

The problem of critical thinking skills in the country is apparent although a recent report says that 97.95 percent of the Philippines is literate but have serious deficiencies in terms of reading comprehension and even critical thinking skills (Brazel, 2020). Some of the problems seen as a contributing factor is the curriculum design which some of the pedagogy are reductive and lacking in terms of developing critical thinking in students (Marquez, 2017). Education curriculum with the influence and rapid growth of globalization where its competencies are designed to fit the market demand which requires more skilled workers. Marquez (2017) argued that is true in the Philippines and opined that Filipino children and youth should not only be sent to schools to be taught skills that would make them competent laborers for capitalist markets, but more importantly, they should be trained to become critical thinkers so as to be open, sensitive, and understanding of the beliefs and values of others as well as not to be enslaved by their respective belief and value systems.

In this fast-paced society, where information is readily available with just one click, the country is facing serious problems related to disinformation (Aïmeur et al., 2923). Many Filipinos are unable to identify what to believe due to a weakened ability to think critically and analyze such information (Lopez. 2024). This has become a challenge for learning institutions. Lansangan & Orleans (2024) argue that learners need to develop skills in selecting appropriate information, assessing its integrity, and making sound decisions. Creating learning spaces that stimulate critical thinking is essential. Brazel (2020) supports this view, stating that to address this problem, educational institutions must shift toward instruction that empowers students to analyze, read between the lines, and identify credible sources for their own work.

In that regard, it is now high time to strengthen our learning institutions as venues for cultivating critical thinking, rather than merely serving as factories that churn out laborers tailored for market demands. While economic preparedness and technical proficiency are essential, education must not lose sight of its deeper, humanistic mission, to shape individuals who can think, discern, and act with integrity. When education is reduced to a market-driven pursuit, students are taught to focus solely on profit, productivity, and performance, often at the cost of moral reasoning, civic consciousness, and self-awareness. The danger here lies not only in what is being taught but also in what is being left out, values, reflection, and the ability to question and reshape society.

This call to reclaim critical thinking aligns with the humanistic tradition in education, which views learners not as passive recipients of information but as thinking, feeling beings with innate worth. Humanistic thinkers such as Carl Rogers (1969), Abraham Maslow (1943), and Erik Erikson (1968) emphasize the importance of self-

actualization, emotional well-being, and moral development. According to Lei (2007), humanistic education brings the learner's inner world, thoughts, emotions, and values, into the center of the educational process. It is an approach that affirms the learner's humanity, and by doing so, opens space for authentic inquiry and critical engagement with the world.

The philosopher Paulo Freire (1970), in his seminal work *Pedagogy of the Oppressed*, argues that true education must liberate, not domesticate. It must engage learners in the process of conscientization, becoming critically aware of their social reality in order to transform it. A society that trains its youth merely to comply with economic demands, without equipping them with the ability to question unjust systems or challenge misleading ideologies, robs itself of democratic vitality. Critical thinking is not a luxury; it is a safeguard of freedom. As Nussbaum (2010) reminds us, democracy requires citizens who can think for themselves, deliberate on what is just, and empathize with others, qualities nurtured not by market-centered education but by a holistic, reflective pedagogy.

Moreover, when education neglects this human capacity to think and align one's actions with personal values and social good, it betrays the very essence of what it means to be human. The ability to reason, to act in accordance with one's conscience, and to seek a meaningful life, these are the marks of a truly educated person. By empowering critical thinking in schools and universities, it affirms this human essence and prepares individuals not only for the workplace, but for life.

Removal of the Ethics Course is Policy-defective and Reduces Education to a Mere Commercial Endeavor

The removal of the Ethics course from the higher education curriculum is not only policy-defective but philosophically irresponsible. This decision disregards the foundational goals of education as enshrined in the 1987 Philippine Constitution, which asserts that education must "foster patriotism and nationalism, accelerate social progress, and promote total human liberation and development" (Philippine Constitution, 1987, Art. II, Sec. 17). Ethics plays a pivotal role in this national vision. Stripping it from higher education is tantamount to stripping education of its moral soul.

The rationale that Ethics is already addressed at the basic education level, through subjects like GMRC and Values Education, is dangerously misguided. As the Union of Societies and Associations of Philosophy in the Philippines (USAPP) pointed out, the function of Ethics in college is not mere obedience to rules but the cultivation of moral reasoning, ethical discernment, and critical engagement with real-world dilemmas. These skills demand a level of cognitive and emotional maturity that is typically present only at the tertiary level. To claim redundancy between high school values subjects and university-level Ethics is to blur the line between moral instruction and philosophical education (USAPP, 2024).

What is more concerning is that this move reflects the growing neoliberal influence in Philippine education, a model that views education primarily as a means to economic productivity rather than human development. Under this framework, courses are assessed based on their "employability value," often at the expense of their formative, ethical, and civic roles (Giroux, 2014; Brown, 2015). Ethics, therefore, becomes expendable in a system that no longer sees students as future citizens but merely as labor-market products. This commodification of education corrodes its deeper purpose.

Furthermore, in our time of moral confusion, marked by political disinformation, normalized corruption, and increasing social apathy, the need for Ethics is more urgent than ever. Ethics provides a space for young people to grapple with questions of justice, truth, and responsibility. It teaches not what to think, but how to think morally and critically. In doing so, it supports the development of responsible, active citizens, a foundation of any democracy. As Imbong (2025) rightly asserts, democracy without ethics is dangerously hollow. A misinformed or morally indifferent majority is a breeding ground for populism, historical distortion, and authoritarian rule. Removing Ethics is not just a curricular adjustment; it is a betrayal of our educational mandate. It undermines the transdisciplinary and humanistic goals that Philippine higher education was meant to uphold. Rather than moving backwards under the pretense of modernization, we must reaffirm the centrality of Ethics in shaping both the moral compass and democratic sensibilities of future generations.

Moreover, the removal of Ethics from the general education curriculum in Philippine higher education. This move is not only policy-defective; it is ethically reckless. Ethics, as a discipline, goes beyond instructing students on what is right or wrong, it cultivates critical thinking, moral discernment, and civic responsibility. To disregard its significance is to deprive future professionals of one of the most essential tools they need to find meaning in this world fraught with ethical complexities.

Removing Ethics, as Maboloc (2025) pointedly argues, is part of a broader neoliberal restructuring of education, one that reduces learning into mechanical skill

acquisition for market ends. When education is treated merely as a means to economic productivity, we betray the vision of education inscribed in the 1987 Philippine Constitution, which mandates education to promote "total human liberation and development" (Art. II, Sec. 17). Ethics is precisely what nurtures this ideal by encouraging students to reflect on human dignity, justice, and the good life.

Some proponents of the removal argue that Ethics is redundant because values education is already present in senior high school. However, this conflates prescriptive instruction in good behavior (as seen in GMRC) with the reflective inquiry that defines college-level moral philosophy. As the UPLB Philosophy Division (2025) clarified, Ethics at the tertiary level deals with complex moral reasoning and philosophical inquiry, skills that require maturity and critical engagement beyond what is feasible in basic education.

Moreover, the suggestion that Ethics is ineffective because it has failed to improve societal morality overlooks the broader socio-political realities at play. Ethics is not a panacea for corruption or moral decay, but rather a formative space where students learn to think critically about ethical dilemmas. It is not about immediate moral transformation, but about building habits of thought and reflection that influence lifelong moral conduct (Newman, 2008).

In a time when misinformation spreads rapidly and moral relativism prevails, Ethics becomes even more indispensable. Students must not merely absorb knowledge; they must be taught how to evaluate, question, and reason through complex moral and social issues. As the Ateneo Philosophy Club (2025) aptly states, Ethics is not just about forming good professionals, it is about forming just citizens.

What is at stake here is not just a single subject in the curriculum, but the very soul of education. By removing Ethics, we risk producing graduates who may be technically competent but morally disoriented, individuals who can perform tasks but lack the discernment to judge whether those tasks are ethical. As Maboloc (2025) warns, no critical thinking means no democracy. Without ethics, we are not educating citizens; we are manufacturing tools. Thus, CHED and all stakeholders reconsider the reform of the curriculum if needed, yes, but never at the cost of moral formation. Education must form both the mind and the conscience. Ethics must stay.

CONCLUSION

Thus, removing the Ethics course from college programs in the Philippines is not just a simple policy defective, it is a serious blow to the heart of what education is meant to be. This paper has shown that Ethics is not just a "nice-to-have" subject. It is a core part of shaping thoughtful, responsible, and engaged citizens in a democracy. Framing its removal as part of educational reform actually reveals something much deeper and more troubling: our education system is drifting toward a market-first mindset that values job skills and economic productivity more than character, critical thinking, and social responsibility. At a time when the world is facing serious ethical challenges, corruption, injustice, division, this shift could not be more dangerous.

Looking at government policies, official memos, and expert opinions, it is clear that the reasoning behind dropping Ethics does not hold up. The idea that students get enough moral training earlier in life, or that it can be casually sprinkled into other subjects, misses the point. College is exactly when students are deciding who they are, what they stand for, and how they want to live and contribute to society. Ethics helps them do that. It is not just about right and wrong, it is about learning how to think through complex issues, listen to others, and grow in empathy and civic responsibility.

Both data and philosophical tradition, from Aristotle to Paulo Freire, support keeping Ethics in higher education. Without it, students may graduate with technical know-how but no real sense of purpose or direction. Other countries, like Finland and the U.S., still prioritize Ethics and the liberal arts because they understand that democracy needs more than just workers, it needs thinkers, leaders, and people with conscience. If we take Ethics out, we risk turning education into a training ground for economic functionaries instead of a place that shapes whole persons.

And the public is noticing. Teachers, philosophers, church leaders, and advocacy groups are pushing back hard, warning that a curriculum without Ethics is a curriculum without soul. In a time when we face misinformation, climate crisis, and institutional failure, we need leaders with moral grounding more than ever. So, taking out Ethics is not just a technical decision, it is a moral mistake. It betrays education's true purpose: to develop people who can think critically, act fairly, and serve the common good. That is why we must urgently rethink this move and recommit to an education that forms not just workers, but wise and compassionate citizens.

Funding: This research received no external funding.

Acknowledgments: I would like to express my gratitude to Tangub City Global College, particularly the Research, Extension, Linkages, and Internationalization (RELI), for their invaluable support and guidance throughout the research process. I am also thankful for the insights and ideas they shared, which greatly contributed to the improvement of this paper. Without their support, this work would not have been possible. I would also like to extend my appreciation to the scholars in the South for voicing their ideas, especially in defending the importance of ethics not only in the curriculum but also in nation-building. This work is likewise dedicated to my students, who continue to inspire me to write about the topic. Critical thinking should never be taken for granted. Freedom is an intangible thing; however, it is one of the things most people desire the most.

Conflicts of Interest: The author declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this study

REFERENCES

Aïmeur, E., Amri, S.,&Brassard, G. (2023). Fake news, disinformation, and misinformation in social media: A review. Social Network Analysis and Mining, 13(1), 30. https://doi.org/10.1007/s13278-023-01028-5

Balan, A. (2023). Neoliberalism, privatisation and marketisation: The implications for legal education in England and Wales. Cogent Education, 10(2). https://doi.org/10.1080/2331186X.2023.2284548

Bar-Tal, D., Vered, S., & Fuxman, S. (2020). Between open-minded critical thinking and closed-minded allegiance: Educational tensions in societies involved in intractable conflict. Political Psychology, 42(5), 779–796. https://doi.org/10.1111/pops.12687

Bautista, M. C. R. B.,&Aranas, M. V. P. (2023, July). The learning crisis in Philippine education: An overview (PolicyNotes No. 2023-17). Philippine Institute for Development Studies.

Cariaso, B. (2025, June 5). DepEd proposal to remove Ethics from curriculum bucked. The Philippine Star. https://www.philstar.com/headlines/2025/06/05/2448347/deped-proposal-remove-ethics-curriculum-bucked

Dano, G. (2024). Strengthening Outcome-Based Education: Capability Approach Perspective. CMU Journal of Science, 28(1), 5–16. https://doi.org/10.52751/cmujs.2024.v28i1.jf2xyq60

Davies, B., & Bansel, P. (2007). Neoliberalism and education. International Journal of Qualitative Studies in Education, 20(3), 247–259. https://doi.org/10.1080/09518390701281751

Delbanco, A. (2012). College: What it was, is, and should be. Princeton University Press.

Desierto, A.,&de Maio, C. (2020). The impact of neoliberalism on academics and students in higher education: A call to adopt alternative philosophies. Journal of Academic Language&Learning, 14(2), 148–159. https://journal.aall.org.au/index.php/jall/article/view/674

Dewey, J. (1916). Democracy and education: An introduction to the philosophy of education. Macmillan.

Edeji, O. C. (2024). Neo-liberalism, human capital theory and the right to education: Economic interpretation of the purpose of education. Social Sciences&Humanities Open, 9, 100734. https://doi.org/10.1016/j.ssaho.2023.100734

Friedman, M. (1962). Capitalism and Freedom. University of Chicago Press.

Giroux, H. A. (2014). Neoliberalism's war on higher education. Haymarket Books.

Haaz, I. (2019). The value of critical knowledge, ethics and education: Philosophical history bringing epistemic and critical values to values (Globethics.net Philosophy Series No. 1). Globethics.net.

Harvey, D. (2005). A brief history of neoliberalism. Oxford University Press.

Harðarson, A. (2019). Aristotle's conception of practical wisdom and what it means for moral education in schools. Educational Philosophy and Theory, 51(14), 1518–1527. https://doi.org/10.1080/00131857.2019.1585240

Imbong, R. A. (2025, June 13). In defense of ethics. Philippine Daily Inquirer. https://opinion.inquirer.net/183882/in-defense-of-ethics

Keast, S. (2020). Psychology education and the neoliberal episteme in Australia. Theory&Psychology, 1–21. https://doi.org/10.1177/0959354320926574

Laird, T. F. N., Niskodé-Dossett, A. S.,&Kuh, G. D. (2009). What general education courses contribute to essential learning outcomes. The Journal of General Education, 58(2), 65–84.

Lopez, M. Y. (2024). A mixed methods study on beliefs and practices pertaining to critical thinking among EFL teachers in Philippine public schools: Implications for policymaking. Manila Journal, 48(3), 15. https://doi.org/10.61871/mj.v48n3-15

Maboloc, C. R. (2025, June 1). Theory and practice: Death of a nation. Edge Davao. https://edgedavao.net/vantage-points/2025/06/theory-and-practice-death-of-a-nation/

McLeod, S. (2024, June 19). Introducing discourse analysis for qualitative research. https://doi.org/10.13140/RG.2.2.15391.57762

Mutuota, R. (2024). Neoliberalism and the barriers in inclusive education. South African Journal of Education, 44(1), Article #2319. https://doi.org/10.15700/saje.v44n1a2319

Noddings, N. (1984). Caring, a feminine approach to ethics&moral education. University of California Press.

Panti, L. T. (2025, May 28). DepEd suggests removing 3 general education subjects from college curriculum. GMA News. https://www.gmanetwork.com/news/topstories/nation/947610/ched-eyes-removal-of-3-general-education-subjects-from-college-curriculum/story/

Patinio, F. (2025, June 9). CEAP opposes proposed removal of Ethics from college curriculum. Philippine News Agency. https://www.pna.gov.ph/articles/1251757

Raaper, R. (2015). Academic perceptions of higher education assessment processes in neoliberal academia. Critical Studies in Education, 57(2), 1–16. https://doi.org/10.1080/17508487.2015.1019901

Rheingold, A. (2012). Nel Noddings' care theory and outdoor education. University of Houston–Clear Lake.

Saad-Filho, A.,&Johnston, D. (Eds.). (2005). Neoliberalism: A critical reader. Pluto Press.

San Juan, D. M. M. (2016). Neoliberal restructuring of education in the Philippines: Dependency, labor, privatization, critical pedagogy, and the K to 12 system. Asia-Pacific Social Science Review, 16(1), 80–110.

Sannadan, J. G. M.,&Lang-ay, P. L. (2021). Neoliberal restructuring in Philippine education: Towards performativity. International Journal of English Literature and Social Science, 6(1).

Sherchan, B., Baskota, P.,&Saud, M. S. (2024). Ethics as a transformational strength in education: An ethical leadership perspective. Advanced Qualitative Research, 2(1). https://doi.org/10.31098/aqr.v2i1.1956

Symons, X.,&VanderWeele, T. (2024). Aristotelian flourishing and contemporary philosophical theories of wellbeing. Journal of Happiness Studies, 25(26). https://doi.org/10.1007/s10902-024-00723-0

Tan, C. (2022). The interpretation of love and its educational realization: A comparative analysis of Nel Noddings' caring and Confucius' ren. Educational Philosophy and Theory, 56(13), 1267–1273. https://doi.org/10.1080/00131857.2022.2075261

Torres, R. C., & Goingo, L. T. (2011). Position paper on the general education curriculum: Concerns and proposed remedies. Gibón, 9, 81–96.

Verma, N. (2024). Education is not only an issue of literate but of learner: A lifelong learning competency. Journal of Research Innovation and Implications in Education, 8, 413–421. https://doi.org/10.59765/mjhy8529

Williams, M. K. (2017). John Dewey in the 21st century. Journal of Inquiry&Action in Education, 9(1), 91–102.

Özkeskin, H., & Gökçe, N. (2025). Neoliberal reconceptualisations of lifelong learning? A critical analysis of learner agency in OECD documents. International Journal of Lifelong Education, 1–16. https://doi.org/10.1080/02601370.2025.2489514

Disclaimer/Publisher's Note: The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of CMUJS and/or the editor(s). CMUJS and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.

CMU Journal of Science
The Official Scientific Journal of Central Mindanao University
ISSN Print: 0116-7847 js.cmu.edu.ph ISSN Online: 2704-3703

Research Article

Beta-Lactam- and Aminoglycoside-Resistant *Vibrio parahaemolyticus* in Marine Food Fish from Four Public Markets in Bukidnon Province, Philippines

Johndel M. Remon[1*], Zeus S. Elumba[1,2], Matilda Grace I. Cempron[1], Joliesa Mae S. Toledo[1,2], and Reggie Y. Dela Cruz[1,2]

1 Molecular Biology and Biotechnology, Genetics, and Microbiology Division, Institute of Biological Sciences, College of Arts and Sciences, Central Mindanao University, Musuan, Maramag, Bukidnon, Philippines

2 Tuklas Lunas Development Center, Central Mindanao University, Musuan, Maramag, Bukidnon, Philippines

* Corresponding author: jdremon46@icloud.com

Citation: Remon, J., Elumba, Z., Cempron, M. G., Dela Cruz, R., & Toledo, J. M. (2026). Beta-Lactam- and Aminoglycoside-Resistant Vibrio parahaemolyticusin Marine Food Fish from Four Public Markets in Bukidnon Province, Philippines. CMU Journal of Science, 30(1), 94

Academic Editor: Dr. Frolan Aya

Received: Dec. 12, 2025
Revised: May 13, 2026
Accepted: June 5, 2026
Published: July 2, 2026

Copyright: © 2024 by the authors. Submitted for possible open access publication under the terms and conditions of the Creative Commons Attribution (CC BY) license (https://creativecommons.org/licenses/by/4.0/).

A B S T R A C T.

Vibrio parahaemolyticus is recognized for its pathogenic potential frequently associated with consumption of contaminated seafood, particularly fish. Although fish constitute a dietary staple in the Philippines, comprehensive data on the prevalence, antimicrobial resistance, and evolutionary relationships of *V. parahaemolyticus* remain scarce. This study assessed the presence of *V. parahaemolyticus* in three commonly consumed marine fishes (*Thunnus albacares*, *Rastrelliger brachysoma*, and *Dussumieria elopsoides*) sourced from public markets in Bukidnon Province using *toxR* gene amplification. Antimicrobial resistance (AMR) was determined for β-lactam and aminoglycosides, and antimicrobial resistant genes (ARGs) were evaluated targeting *blaCARB*, *blaCARB17*, *strA*, and *strB* genes, through the Kirby-Bauer method and PCR, respectively. Phylogeny was determined comparing *toxR* gene sequences using the NJ method at 1,000 bootstraps. Out of the nine isolates, seven have demonstrated resistance to ampicillin, three to ceftazidime, and seven to gentamicin. The *blaCARB* gene was identified in four isolates, confirming phenotypic resistance to ampicillin and ceftazidime. However, no isolates are identified carrying *strA* and *strB* genes despite phenotypic resistance to aminoglycoside. BLAST-based analysis of *toxR* sequences confirmed high percent identity (99.67-100%) with reference *V. parahaemolyticus* sequences in the NCBI database, validating species-level identification. Phylogeny indicated 83-100% sequence similarity among isolates, reflecting intra-species genetic diversity. Findings document the presence of β-lactam- and aminoglycoside-resistant *V. parahaemolyticus* in marine food fish, highlighting the necessity for enhanced seafood safety protocols. As one of the most common seafood-borne pathogens, the presence of this bacterium underscores the importance of ongoing AMR surveillance to mitigate food safety risks, particularly for consumers of raw fish.

Keywords: *Vibrio parahaemolyticus*, antimicrobial resistance, beta-lactam, aminoglycoside, public markets, marine fishes

INTRODUCTION

Vibrio parahaemolyticus is a Gram-negative, halophilic bacterium that naturally inhabits marine and estuarine waters (Fang et al., 2023), and a major seafood-borne pathogen that causes infections, particularly gastroenteritis linked to undercooked or raw seafood consumption (Bourdonnais et al., 2024; Tada et al., 1992). Gastroenteritis infection caused by this bacterium is generally self-limiting, and could be treated with antibiotics, but their misuse or abuse can lead to the emergent of resistant strains (Bourdonnais et al., 2024; Chiou et al., 2015; Diemert, 2006; Su & Liu, 2007). Marine food fish are a common vehicle for the transmission of *V. parahaemolyticus* to humans. Fish is a dietary staple and an affordable source of protein in the Philippines, with the fisheries sector contributing approximately 1.5% to the national GDP (SEAFDEC, 2022). Despite its nutritional and economic importance, an information gap remains regarding *V. parahaemolyticus* contamination in marine food fish sold in local markets, as well as antimicrobial resistance profile and genetic relationship between *V. parahaemolyticus* isolates from different market sources.

The *V. parahaemolyticus* pathogen possesses several virulence factors, including the primary virulence factors thermostable direct hemolysin (TDH), and TDH-related hemolysin (TRH), both of which exhibit hemolytic activity (Honda et al., 1992; Honda & Iida, 1993; Kishishita et al., 1992). Additionally, it harbors three distinct type III secretion systems (T3SS1, T3SS2α, and T3SS2β) that contribute to enterotoxic and/or cytotoxic effects (Ham & Orth, 2012). It has been demonstrated that these virulence factors are regulated by the ToxR protein composed of 20 genes that encode products promoting intestinal colonization, toxin production, and host survival (DiRita et al., 1991). Specifically, the *toxR* gene, a regulatory gene of the toxin operon in *Vibrio* and part of the ToxR protein, is involved in the regulation of virulence genes (Kim et al., 1999; Sechi et al., 2000). Detection of virulence genes in *V. parahaemolyticus* is primarily used for determining pathogenic strains. However, *toxR* gene, aside from its primary function as a regulator for the expression of virulence factors, can be used to identify both pathogenic or non-pathogenic *V. parahaemolyticus* (Sechi et al., 2000). Although *toxR* is not directly responsible for encoding major hemolysins, its regulatory influence over virulence-associated pathways renders it a reliable molecular indicator of pathogenic potential (Letchumanan et al., 2014). Comparative sequence analyses have revealed that while *toxR* is conserved across multiple *Vibrio* species, it exhibits species-specific polymorphisms that enable its use as a molecular marker for species-level identification. For instance, the gene sequence in *V. parahaemolyticus* demonstrates sufficient divergence from homologous sequences in closely related species such as *Vibrio alginolyticus* and *Vibrio cholerae*, thereby facilitating its application in PCR-based diagnostics for accurate detection and differentiation (Kim et al., 1999; Montieri et al., 2010).

In addition to the virulence factors of *V. parahaemolyticus*, the rise and emergence of antimicrobial resistance (AMR) in *V. parahaemolyticus* strains is becoming a major public health concern for countries with seafood-consuming populations. AMR is the ability of bacteria to survive and grow despite exposure to drugs intended to inhibit or eliminate them (FAO, 2024). The evolution of AMR in *Vibrio* species, including *V. parahaemolyticus*, is primarily linked to the widespread use of antibiotics in aquaculture and clinical settings (Gould, 2016). Evidence of AMR has been detected in some clinical and environmental isolates of *V. parahaemolyticus*, where excessive antibiotic use promotes the positive selection of antimicrobial resistance genes (ARGs), thereby accelerating their spread among microbial populations (Zhang et al., 2022). Like other bacteria, the mechanism of antibiotic resistance developed by *V. parahaemolyticus* can be classified as either intrinsic or acquired through horizontal gene transfer (HGT) (Dutta et al., 2021). However, genetic determinants that confer antimicrobial resistance in bacteria are also found in plasmids (Bennett, 2008; Szczepanowski et al., 2009), which serve as mediators for the transfer of antibiotic-resistant genes via HGT (Okamoto et al., 2009; Wang et al., 2024). Molecular-level assessment of AMR in *V. parahaemolyticus* is a vital component of AMR surveillance that could offer insights into the genetic determinants and mechanisms that drive resistance.

This study aimed to characterize and confirm identification of the putative *V. parahaemolyticus* isolates from market marine fish samples through *toxR* gene detection, evaluate the antimicrobial resistance and molecular phylogeny of antimicrobial-resistant *V. parahaemolyticus* isolates and analyze their antimicrobial resistance genes.

METHODOLOGY

Screening of Isolates

Presumptive *V. parahaemolyticus* isolates were previously obtained from yellowfin tuna (*Thunnus*

albacares), short-bodied mackerel (*Rastrelliger brachysoma*), and sardine (*Dussumieria elopsoides*) samples collected from four public markets in Bukidnon Province, Philippines, namely Valencia City Central Market, Maramag Public Market, Malaybalay City Public Wet Market, and Quezon Central Market. The fish samples were selected based on the top fish species consumed by the local provincial population. For each market, 3 samples per species were collected between the months of July to September of 2024, during rainy seasons. Of the 36 fish samples collected, at least 35 presumptive isolates showing round-green colonies were obtained and were subjected for further characterization. However, only a few isolates were selected for *toxR* and AMR genes sequencing. These isolates were selected based on characteristics, particularly on the presence of *toxR* genes, and virulence genes (*tdh* and *trh*) upon PCR amplification and antimicrobial resistance phenotypes, ensuring variation based on locations, and were re-cultured on thiosulfate-citrate-bile salts-sucrose (TCBS, HiMedia®) agar plates. A total of nine isolates were recovered and subsequently screened using Gram staining to confirm their morphological characteristics, as curved rod-shaped and Gram-negative. Upon re-culture, each isolate was labeled based on their market and sample sources (Table 1).

Table 1. Labeling system for the isolates.

Isolate number	Market source	Sample source	Occurrence per sample	Code
1	Valencia City	Sardine	1	CVH3.1
2	Valencia City	Short-bodied mackerel	1	CVM1.1
3	Maramag	Short-bodied mackerel	1	MMT1.1
4	Malaybalay City	Sardine	1	CMH3.1
5	Malaybalay City	Short-bodied mackerel	1	CMM1.1
6	Malaybalay City	Yellowfin tuna	1	CMT1.1
7	Quezon	Sardine	1	MQH2.1
8	Quezon	Short-bodied mackerel	1	MQM3.1
9	Quezon	Yellowfin tuna	1	MQT1.2

The isolates were labeled based on the initial of the common name of the fish, a sample collection number specific to the fish species, and an isolate identifier for each purified strain from the sample. For example, in the code CVM1.1, "CV" indicates the sampling site (City of Valencia), "M" corresponds to the fish common name (Mackerel), "1" designates the first mackerel sample out of three collected at that site, and ".1" denotes the first distinct isolate purified from this sample. For the case of sardine, "H" was used, since the isolates were obtained prior to the sample identification, pre-identified as "Herring."

Molecular Characterization

DNA isolation for each isolate was carried out using the boiling lysis method described by Jones et al. (2012). The DNA purity was measured using the standard A260/A280 ratio to align with the acceptable values between 1.8 to 2.0. PCR amplification of the *toxR* gene was performed using the *V. parahaemolyticus toxR*-specific primer, with a target yield of 368 bp PCR product (Parthasarathy et al., 2021). The primer sequences used were as follows: F 5′-GTC TTC TGA CGC AAT CGT TG-3′ and R 5′-ATA CGA GTG GTT GCT GTC ATG-3′ (Kim et al., 1999). Each 20 µL PCR reaction consisted of 0.1 µL of 0.5 U Ex Taq polymerase, 2.0 µL of 10X PCR reaction buffer (Ex Taq Buffer; Takara, Japan), 1.6 µL of 0.2 mM each dNTP, 5.0 µL of DNA Template, 0.24 µL each of 0.03 µM primer, and 10.82 µL of sterile ultra-pure water. PCR amplifications were performed in a T100TM thermal cycler (Bio-Rad; California, United States), with the following conditions: 20 cycles of amplification, consisting of denaturation (94 °C for 1 minute); annealing (63 °C for 1 minute and 30 seconds); and extension (72 °C for 1 minute and 30 seconds) (Kim et al., 1999). Sequencing was performed by Macrogen, Inc. (Seoul, South Korea), using the BigDye® Terminator v3.1 cycle sequencing kit (Applied Biosystems; Massachusetts, United States) on an ABI PRISM 96-capillary 3730XL DNA analyzer. The BioEdit Sequence Alignment Tool was used to trim and align the DNA sequences obtained. The sequences were then analyzed for similarity using the nucleotide BLAST (BLAST-n) tool on the NCBI website, with the nucleotide collection (nr/nt) database selected as the target for sequence comparison. To elucidate for the phylogeny, *toxR* sequences were subjected to MEGA11 software by multiple sequence alignment using MUSCLE, and evolutionary relationships were determined using the neighbor-joining (NJ) method with 1,000 bootstrap replicates, with evolutionary distances

between sequences were calculated using the maximum composite likelihood method.

Antibiotic Susceptibility Profiling

The nine (9) isolates were subjected to antibiotic susceptibility testing using the Kirby-Bauer method against eight (8) antibiotics, and were incubated at 35 °C for 18 hours, following the guidelines of the Clinical and Laboratory Standards Institute (CLSI) document M45, 3rd edition, for *Vibrio* spp (CLSI, 2016). The 8 antibiotic discs were placed on MHA plates with a control disc containing 10 µL distilled water. The selected antibiotic discs (Bioanalyse®; Ankara, Türkiye) represented classes that inhibit bacterial cell wall synthesis, DNA synthesis, and protein synthesis, addressing different mechanisms of action (Elmahdi et al., 2016; Lopatek et al., 2018; Tabo et al., 2015). Four (4) antibiotics, to which some *V. parahaemolyticus* strains exhibit high resistance, were included: 10 µg ampicillin (AM10); 30 µg ceftazidime (CAZ30); 10 µg gentamicin (CN10); and 30 µg tetracycline (TE30). Another four (4) antibiotics were also included, where *V. parahaemolyticus* strains generally show high susceptibility: 10 µg meropenem (MEM10); 5 µg ciprofloxacin (CIP5); 1.25/23.75 µg trimethoprim-sulfamethoxazole (SXT25); and 30 µg chloramphenicol (C30). Multi-drug resistance among isolates was assessed following the definition of Magiorakos et al. (2012), where isolates that show non-susceptibility (i.e., resistant or intermediate) to ≥ 1 agent in ≥ 3 antimicrobial classes are considered multidrug-resistant (MDR).

Resistome Analysis

The nine (9) isolates were screened for AMR genes based on phenotypic resistance patterns in antibiotic susceptibility tests, referencing previous studies on AMR genes within *V. parahaemolyticus* isolates. PCR amplification was conducted using synthesized oligonucleotide primers (Table 2) designed to target specific AMR genes associated with known resistance mechanisms. The PCR procedures and sequencing were performed by Macrogen, Inc. (Seoul, South Korea), with the same procedures for *toxR* sequencing mentioned earlier. For PCR amplification, DNA extraction was performed using InstaGene Matrix (Bio-Rad; California, United States). Since the annealing temperature for each primer was undetermined, gradient PCR amplification was followed by mixing DNA template with Taq polymerase MBAE-110 AxenTM H Taq PCR Master Mix (2X). Amplification was done using DNA Engine Tetrad 2 Peltier Thermal cycler (Bio-Rad; California, United States) to obtain ~500 bp for *blaCARB*, ~303 bp for *blaCARB17*, ~500 bp for *strA*, and ~500 bp for *strB*, with the following conditions: initial denaturation (95 °C for 5 minutes); followed by 35 cycles of denaturation (95 °C for 30 seconds); annealing at different temperatures (48 °C, 49.4 °C, 51.8 °C, 55.5 °C, 60 °C, 63.9 °C, 66.4 °C, and 68 °C for 30 seconds); and extension (72 °C for 1 minute); with a final extension (72 °C for 10 minutes). Gel electrophoresis was followed using 2 µL each of PCR DNA product in 1.5% agarose gel, stained with Gel Red, and run at 300 V for 20 minutes. Thermo Fisher Scientific (California, United States) GeneRuler DNA Ladder Mix (#SM0331) was used as a DNA marker.

Table 2. Primer sets for the detection of antimicrobial resistance (AMR) genes.

AMR gene(s)	Primer sequence(s) (5′–3′)	amplicon size (~bp)	Reference(s)
blaCARB	F: 5′-GCT GAG AGC TCA TGA AAA AGT TA-3′ R: 5′-CGT AGG ATC CTT AAC TTT ATT TGT AGT GC-3′	~ 500	Wang et al. (2022), Zhang et al. (2024)
blaCARB17	F: 5′-ACC TTT GAT GGA AGA TA-3′ R: 5′-TCT AAC TTT CTT TGT AGT GCA-3′	~ 303	Hu et al. (2021), Li et al. (2016)
aph(3″)-Ib (*strA*)	F: 5′-TGG CAG GAG GAA CAG GAG G-3′ R: 5′-AGG TCG ATC AGA CCC GTG C-3′	~ 500	Zhang et al. (2024), Zhang et al. (2017)
aph(6)-Id (*strB*)	F: 5′-ATC GTC AAG GGG ATT GAA ACC-3′ R: 5′-GGA TCG TAG AAC ATA TTG GC-3′	~ 500	Zhang et al. (2024), Zhang et al. (2017)

RESULTS AND DISCUSSION

Phylogenetic Tree Analysis

The BLAST-based similarity analysis of the *toxR* sequences for each isolate revealed high sequence identity (99.67% to 100.00%), and E-values consistently

recorded at 0.00. In the context of BLAST (Basic Local Alignment Search Tool), the E-value represents the expected number of alignments with a given score that could occur by chance in a database of a particular size, wherein an E-value of 0.00 indicates an extremely low probability of random alignment, thereby signifying a highly significant match between the query and reference sequences. This statistical measure is significant in confirming the authenticity of sequence homology, especially when the percent identity is near-perfect (Altschul et al., 1990). Among the nine (9) isolates, eight exhibited 100.00% identity to established *V. parahaemolyticus* reference sequences in the NCBI nucleotide collection (nr/nt) database. The remaining isolate, MMT1.1, showed a slightly lower identity of 99.67%, yet still retained an E-value of 0.00, supporting the reliability and biological relevance of the match. Furthermore, query coverage values ranged from 99.00% to 100.00% across all sequences, indicating that nearly the entire length of each query sequence aligned with the reference, thus supporting accurate taxonomic identification of the isolates as *V. parahaemolyticus* (Table 3).

Table 3. Top BLAST-n hits for each isolate derived from *toxR*-based genomic DNA sequence analysis.

Scientific name	Accession number	Max score	Total score	Query cover	E-value	Percent identity
Isolate CMH3.1						
Vibrio parahaemolyticus	AB300873.1	551	551	100%	0.00	100%
Isolate CMM1.1						
Vibrio parahaemolyticus	CP046782.1	549	549	100%	0.00	100%
Isolate CMT1.1						
Vibrio parahaemolyticus	CP046782.1	551	551	100%	0.00	100%
Isolate CVH3.1						
Vibrio parahaemolyticus	CP078655.1	549	549	100%	0.00	100%
Isolate CVM1.1						
Vibrio parahaemolyticus	CP150902.1	520	520	100%	0.00	100%
Isolate MMT1.1						
Vibrio parahaemolyticus UCM-V49	CP007004.1	558	558	100%	0.00	99.67%
Isolate MQH2.1						
Vibrio parahaemolyticus	CP150902.1	551	551	100%	0.00	100%
Isolate MQM3.1						
Vibrio parahaemolyticus	CP078641.1	569	569	99%	0.00	100%
Isolate MQT1.2						
Vibrio parahaemolyticus	CP078611.1	562	562	100%	0.00	100%

The evolutionary relationships among various *Vibrio* species, based on the *toxR* gene sequences, with a focus on multiple isolates of *V. parahaemolyticus* (from this study), and *Photobacterium damselae* subsp. *damselae*, as the outgroup, are presented in Figure 1. The placement of the outgroup *Photobacterium damselae* confirms its status as the most distantly related species among those included in the phylogenetic tree, providing a reference point for inferring the evolutionary direction of the isolates and other *Vibrio* species.

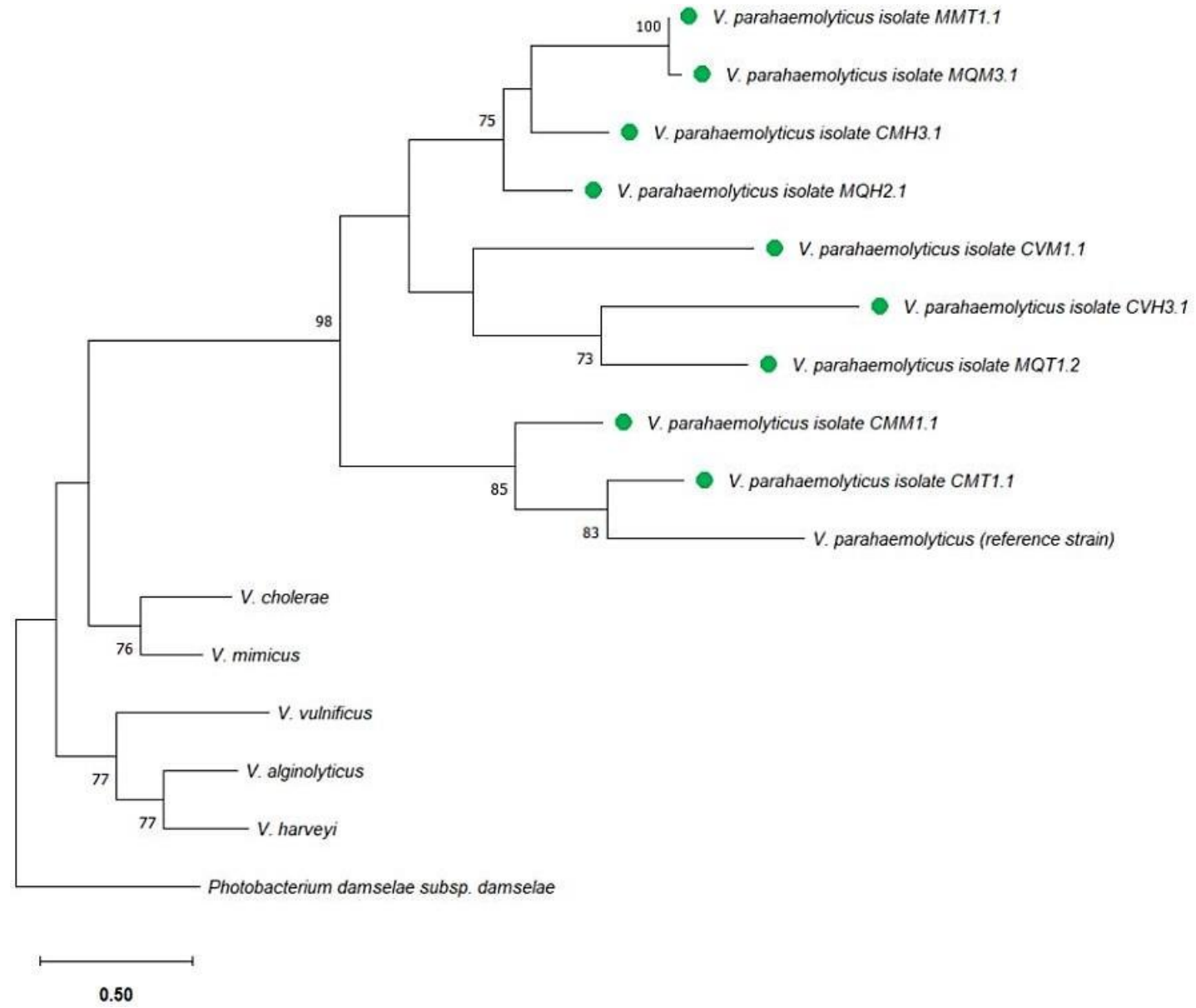


Figure 1. Phylogenetic tree illustrating the placement of *V. parahaemolyticus* isolates (indicated by green bullets), constructed using sequences of the *toxR* gene. The tree includes various *Vibrio* species for comparative analysis, with *Photobacterium damselae* subsp. *damselae* serving as the outgroup.

Among the five *Vibrio* species included in this analysis, *V. harveyi* and *V. alginolyticus* appear to be closely related (77% bootstrap value), supporting their shared node. Further up the tree, *V. vulnificus* branches off next, suggesting a closer evolutionary relationship with the previously mentioned two species compared to the other species included in the analysis. On the other hand, *V. mimicus* and *V. cholerae* cluster together, having close evolutionary history reflected (76% bootstrap value) within their shared node, consistent with previous studies reporting genetic similarities between these two species, particularly in terms of ecological adaptations (Halder et al., 2022).

The largest clade in the tree is composed of nine *V. parahaemolyticus* isolates (from this study) and a GenBank-derived reference strain of *V. parahaemolyticus* (GenBank Accession Number: AB029915.1) from NCBI. Strains in this clade have high genetic similarity, which is evident in their bootstrap values of 73-100%. Wherein, the reference strain closely aligns with the isolate CMT1.1 at 83% bootstrap value. Within the same cluster, isolate CMM1.1 diverges slightly from the previously mentioned pair at 85%. Further branching shows that isolates MQT1.2, CVH3.1, and CVM1.1 form a subcluster (≥73%). Isolates MQH2.1 and CMH3.1 are closely positioned higher than the previously mentioned isolates, and isolates MMT1.1 and MQM3.1 have the highest similarity (100%), indicating a well-supported genetic similarity within their *toxR* sequences. The phylogenetic tree topology likely reflects consistent bootstrap support

across branches, affirming the reliability and stability of the inferred phylogenetic relationships among isolates. This interpretation is further supported by a finding that bootstrap proportions of ≥70% generally correspond to a probability of ≥95% that the associated clade represents a true evolutionary relationship (Hillis & Bull, 1993). Thus, the presence of high bootstrap values across the branches of the phylogenetic tree further strengthens the reliability and validity of the inferred clades. Moreover, the close clustering observed between the GenBank-derived *V. parahaemolyticus toxR* sequences and the isolates obtained in this study suggests a high degree of genetic conservation within this group despite having differences in their environmental sources. This clustering may indicate that the isolates from the public markets share common contamination pathways, potentially from seafood samples or aquatic environments in Mindanao. Furthermore, the clustering pattern may reflect cross-contamination associated with market handling practices, such as processing, transportation, storage, and retail distribution, which could contribute to the spread of closely related *V. parahaemolyticus* strains across different marine fish samples. Similar observations were reported by Elhadi et al. (2004), who documented the occurrence of diverse potentially pathogenic *Vibrio* species in Malaysian seafood products, attributing contamination to poor hygiene and inadequate seafood marketing systems, where *V. parahaemolyticus* was detected across several shellfishes, suggesting previous claims. Likewise, Parthasarathy et al. (2021) reported that *V. parahaemolyticus* contamination in fishes was strongly influenced by environmental exposure and cross-contamination during market handling, particularly through contact with contaminated shellfish products. In spite of genetic variations, the proximity of the GenBank-derived *V. parahaemolyticus toxR* sequence to the isolates from Bukidnon markets, provides internal confirmation of accurate species identification. This highlights the consistency between the molecular characteristics of the isolates and the known genetic profile of *V. parahaemolyticus*, which is obtained in NCBI. On the other hand, the formation of separate clade for other *Vibrio* indicates that they may have followed different evolutionary paths. This inclusion provides valuable comparative insights into both the evolutionary relationships and genetic distinctions among members of the genus at the *toxR* sequence level. Since the *toxR* is commonly associated with species identification and regulatory functions in *Vibrio*, variation within this gene may serve as evidence of species-level divergence while also demonstrating conserved evolutionary relationships among closely related taxa (Sawabe et al., 2007). Previous studies have likewise demonstrated that phylogenetic clustering based on the *toxR* gene sequences can reveal ecological adaptation and evolutionary relatedness, particularly those associated with seafood and aquatic environments (Kim et al., 1999; Sawabe et al., 2007).

Furthermore, understanding the linkages between these clustered isolates and specific market-handling or supply-chain practices is important in bridging the gap between phylogenetic findings and practical public health implications. Such insights can guide regulators in implementing targeted interventions to mitigate contamination risks, thereby translating phylogenetic findings into actionable strategies to strengthen seafood safety. The *Vibrio* species derived in NCBI included in this study are recognized for their roles in seafood-associated infections and diseases affecting aquatic animals, seafood products, and consumers. Incorporating these *Vibrio* species into this analysis may provide a comparison for assessing how the *toxR* gene varies among species with distinct pathogenic profiles and ecological adaptations, as the regulatory gene of these pathogens (Miller & Mekalanos, 1988). By examining *toxR* gene sequence variations among different *Vibrio* species, a comparison can be made regarding how evolution has shaped differences in gene structure and function. This often reflects adaptation to specific environmental conditions and may also influence the virulence potential of each species (Kim et al., 1999). In contrast to this comparison, the 16S rRNA sequences of *V. parahaemolyticus* and *V. alginolyticus* share high similarity at 99%. However, their *toxR* gene sequences are more distinct, allowing *toxR* to be a better marker for species-level differentiation in *Vibrio* species (Montieri et al., 2010). Furthermore, the *toxR* gene functionally encodes a membrane-bound transcriptional regulator that modulates key virulence genes. This gene activates cholera toxin and toxin-coregulated pilus genes in *V. cholerae*, while it regulates hemolysin production in *V. parahaemolyticus*, which are thermostable direct hemolysin or TDH-related hemolysin (TDH/TRH), and type III secretion systems (T3SS1, T3SS2α, and T3SS2β) (Lin et al., 1993).

Sequence-based comparisons of the *toxR* gene may provide insights into the functional divergence of virulence regulation, helping to explain why certain *Vibrio* species are more frequently associated with human disease (Zhang et al., 2018). The phylogenetic relationship of these strains carries significant implications for both molecular epidemiology and public health surveillance in *V. parahaemolyticus*, as a leading cause of seafood-associated gastroenteritis. Moreover, mapping its genetic diversity is critical for identifying virulent strains and tracking contamination sources in aquaculture, processing chains (Ceccarelli et al., 2013), market settings as well.

Antimicrobial Resistance of the Isolates

Antimicrobial resistance profiling of the nine (9) isolates revealed a high level of resistance to β-lactam

antibiotics, including cephalosporins. Seven (7) isolates exhibited resistance to ampicillin (77.78%), while three (3) were resistant to ceftazidime (33.33%), consistent with previous studies reporting elevated β-lactam resistance in *V. parahaemolyticus* isolated from seafood (Elmahdi et al., 2016; Tan et al., 2020) and in aquaculture environments (Siddique et al., 2021). This observed resistance patterns may reflect frequent exposure of this pathogen to β-lactam antibiotics, where amoxicillin, cephalosporins, penicillin, ampicillin, cephalexin, cefradine, and cefotaxime (Lulijwa et al., 2020) have been widely used in aquaculture industry in several countries, such as Brazil, Italy, Turkey, Korea, and South Africa (Bondad-Reantaso et al., 2023; Fri et al., 2018; Helena Rebouças et al., 2011; Kang et al., 2017; Laganà et al., 2011; Ozaktas et al., 2012). In addition, seven (7) isolates exhibited resistance to the aminoglycoside antibiotic gentamicin (77.78%) used in this study (Table 4). Multidrug resistance was not observed among the nine isolates, as none exhibited resistance or intermediate resistance to more than one antibiotic in at least three different antimicrobial classes (Magiorakos et al., 2012).

Table 4. Phenotypic resistance observed in nine (9) isolates based on antibiotic susceptibility profiling interpreted using the CLSI M45 guidelines for Vibrio.

			β-lactams							
			Penicillin	Cephem	Carbapenem	Aminoglycoside	Tetracycline	Fluoroquinolone	Folate pathway inhibitor	Phenicol
Isolate name	**Fish source**	**Market source**	**AM**	**CAZ**	**MEM**	**CN**	**TE**	**CIP**	**SXT**	**C**
CVH3.1	Sardine	Valencia City	R	R	S	R	S	S	S	S
CVM1.1	Short-bodied Mackerel	Valencia City	S	I	S	R	S	S	S	S
MMT1.1	Short-bodied Mackerel	Maramag	I	S	S	I	S	S	S	S
CMH3.1	Sardine	Malaybalay City	R	I	S	R	S	S	S	S
CMM1.1	Short-bodied Mackerel	Malaybalay City	R	R	S	R	S	S	S	S
CMT1.1	Yellowfin Tuna	Malaybalay City	R	R	S	R	S	S	S	S
MQH2.1	Sardine	Quezon	R	I	S	R	S	S	S	S
MQM3.1	Short-bodied Mackerel	Quezon	R	S	S	R	S	S	S	S
MQT1.2	Yellowfin Tuna	Quezon	R	S	S	I	S	S	S	S

Abbreviations: AM, ampicillin; CAZ, ceftazidime; MEM, meropenem; CN, gentamicin; TE, tetracycline; CIP, ciprofloxacin; SXT, trimethoprim-sulfamethoxazole; C, chloramphenicol; R, resistant; I, intermediate; and S, susceptible.

Genomic Resistome

The genomic resistome was based on sequence analysis of isolates with phenotypic resistance to antibiotics employed in this study. The *blaCARB* gene was detected in four (4) out of seven (7) isolates (57.14%) with phenotypic resistance to ampicillin (CVH3.1, CMH3.1, CMT1.1, and MQT1.2), and two (2) out of three (3) isolates (66.67%) with phenotypic resistance to ceftazidime (CVH3.1 and CMT1.1). Despite the absence of detection in some isolates, this finding provides strong molecular evidence of β-lactam antibiotic resistance, demonstrated by phenotypic resistance, particularly to ampicillin and ceftazidime. The *blaCARB*-positive isolates, sourced from sardines and yellowfin tuna, may indicate that seafood can serve as a reservoir for antimicrobial-resistant bacteria, posing a potential public health risk. However, it is important to acknowledge some limitations in this study. The PCR primer sets used may not cover all variants of antimicrobial resistance genes, potentially missing some forms of resistance. In addition, the sample size of isolates might limit the generalizability of the results.

The *blaCARB* gene encodes a class A carbenicillin-hydrolyzing β-lactamase in bacteria that confers resistance by hydrolyzing β-lactam antibiotics, rendering them ineffective (Chiou et al., 2015). Recent genomic surveillance studies have shown that the gene is frequently detected in *V. parahaemolyticus* strains isolated from seafood-borne outbreaks. For instance, isolates from outbreaks in Huzhou, China, exhibited high resistance rates to ampicillin and often carried the *blaCARB* gene, especially among strains of the emerging serotype O10:K4. This may support the claims that the gene is intrinsic (Yan et al., 2024). However, this resistance may also be under selective pressure from the use of antibiotics in aquaculture and food production systems (Yan et al., 2024). Although not directly investigated, the co-occurrence of resistance to third-generation cephalosporins, such as ceftazidime, may suggest the presence of additional resistant determinants, likely acquired through the mobilization of

mobile genetic elements (MGEs) carrying multiple AMR genes (Singh et al., 2018).

On the other hand, the non-detection of *aph(3")-Ib* (*strA*) and *aph(6)-Id* (*strB*) genes in seven (7) isolates having phenotypic resistance to aminoglycosides may suggest that there could be alternative resistance mechanisms. These two genes typically encode aminoglycoside-modifying enzymes (AMEs), specifically phosphotransferases that inactivate antibiotics such as streptomycin through the process of phosphorylation. Their detection is common in Enterobacteriaceae and *Pseudomonas* spp., where they are often carried on MGEs (Jana & Deb, 2006). However, in *V. parahaemolyticus*, aminoglycoside resistance may not be mediated solely by *strA* and *strB*, which are the canonical AME genes, used in this study. *V. parahaemolyticus* biofilms can develop resistance to aminoglycosides through multiple non-genetic mechanisms. These include biofilm enclosure that physically limits antibiotic penetration, neutralization via anionic extracellular polymeric substances (EPSs), and regulatory responses that upregulate resistance-associated genes under antibiotic stress. This further suggest that resistance may be phenotypically expressed without the presence, or the PCR-detectable presence of canonical AME genes (Tian et al., 2023). Moreover, whole-genome sequencing of environmental *V. parahaemolyticus* strains has revealed a diverse resistome, including efflux pumps, permeability barriers, and other AME genes beyond *strA* and *strB*, such as *aac(3)-IIa* and *aadA* (Song et al., 2024), which have not been targeted by PCR amplification. The failure to detect *strA* and *strB* genes may also be due to sequence variation in primer binding regions, gene silencing, or low copy number, all of which can hinder amplification from genomic DNA (Sundin, 2000).

CONCLUSION

Results from this study affirm that the putative isolates obtained from public markets across Bukidnon Province in the Philippines, were *V. parahaemolyticus*, based on *toxR* gene sequence analysis using BLAST-n and molecular phylogenetic comparison with GenBank-retrieved *V. parahaemolyticus toxR* sequences. Despite geographical differences among market sites, phylogenetic analysis revealed that all isolates were genetically related, exhibiting sequence similarities based on bootstrap values, ranging from 73 to 100%. Furthermore, majority of the isolates demonstrated resistance to selected antibiotics, particularly those belonging to β-lactam and aminoglycoside classes. β-lactam resistance was especially evident in four (4) isolates in which the *blaCARB* gene was detected. However, ARGs are not detected in some β-lactam-resistant and aminoglycoside-resistant isolates, despite phenotypic observations. These discrepancies may be attributed to some limitations in the study, particularly that the PCR primer sets used may not cover all variants of antimicrobial resistance genes, potentially missing some forms of resistance. These findings could highlight a pressing threat to food safety and public health, further emphasizing the adaptive potential of potentially pathogenic *V. parahaemolyticus*. Nevertheless, the study has several limitations, which have not been given a focus, where isolates were pre-selected based on their phenotypic resistance, virulence associated characteristics, and the presence of *toxR* gene, thereby limiting the representation of environmental variability and the determination of the occurrence across individual markets and throughout Bukidnon Province. The findings in this study highlight a significant public health concern, particularly if not addressed effectively through an effective One Health approach. This study further suggests the urgent need for stricter veterinary oversight on antibiotic use in aquaculture and the enforcement of stronger sanitation and food safety regulations. Future studies should adopt a more comprehensive approach that integrates ecological, epidemiological, and molecular approach, by investigating contamination pathways, expanding sampling technique to include both wet and dry seasons, and conducting comparative genomic analyses, to ARGs and other virulence-associated determinants.

Author Contributions: JMR (conceptualization, formal analysis, investigation, methodology, visualization, writing - original draft, writing - review and editing); ZSE (conceptualization, data curation, formal analysis, methodology, project administration, supervision, validation, visualization, writing - original draft, writing - review and editing); MGIC (conceptualization, methodology, and visualization); JMST (conceptualization, methodology, validation, writing - review and editing); and RYDC (conceptualization, methodology, resources, validation, writing - review and editing).

Funding: This research was funded by the Department of Science and Technology – Science Education Institute (DOST – SEI) through the Project STRAND scholarship granted for the primary author.

Data Availability Statement: The data generated and analyzed during this study are included in this article. Any raw data supporting the findings of this study are available from the corresponding author upon reasonable request.

Acknowledgments: The authors acknowledge the Department of Science and Technology – Science Education Institute (DOST–SEI) project STRAND for the scholarship granted for the primary author, the Institute of Biological Sciences at Central Mindanao University, Tuklas Lunas Development Center, Local Government Units of Malaybalay City, Valencia City, Maramag, and Quezon, in Bukidnon, Philippines. The authors also acknowledge the invaluable assistance, expertise, and guidance of Nekka A. Mondaga, Kristina Casandra Pava, Walter Clint Bayani, Dr. Michelle Suelo, and Dr. Glenda Doblas.

Conflicts of Interest: The authors declare that there are no conflicts of interest.

REFERENCES

Altschul, S. F., Gish, W., Miller, W., Myers, E. W., & Lipman, D. J. (1990). Basic local alignment search tool. Journal of Molecular Biology, 215(3), 403–410. https://doi.org/10.1016/S0022-2836(05)80360-2

Bennett, P. M. (2008). Plasmid encoded antibiotic resistance: Acquisition and transfer of santibiotic resistance genes in bacteria. British Journal of Pharmacology, 153(S1). https://doi.org/10.1038/sj.bjp.0707607

Bondad-Reantaso, M. G., MacKinnon, B., Karunasagar, I., Fridman, S., Alday-Sanz, V., Brun, E., Le Groumellec, M., Li, A., Surachetpong, W., Karunasagar, I., Hao, B., Dall'Occo, A., Urbani, R., & Caputo, A. (2023). Review of alternatives to antibiotic use in aquaculture. Reviews in Aquaculture, 15(4), 1421–1451. https://doi.org/10.1111/raq.12786

Bourdonnais, E., Briet, A., Brauge, T., Debuiche, S., Helsens, N., Granier, S. A., & Midelet, G. (2024). Antimicrobial susceptibility profile and molecular characterization of Vibrio parahaemolyticus strains isolated from imported shrimps. Microbiology Spectrum, 12(7), e00175-24. https://doi.org/10.1128/spectrum.00175-24

Ceccarelli, D., Hasan, N. A., Huq, A., & Colwell, R. R. (2013). Distribution and dynamics of epidemic and pandemic Vibrio parahaemolyticus virulence factors. Frontiers in Cellular and Infection Microbiology, 3. https://doi.org/10.3389/fcimb.2013.00097

Chiou, J., Li, R., & Chen, S. (2015). CARB-17 Family of β-Lactamases Mediates Intrinsic Resistance to Penicillins in Vibrio parahaemolyticus. Antimicrobial Agents and Chemotherapy, 59(6), 3593–3595. https://doi.org/10.1128/AAC.00047-15

CLSI. (2016). Methods for antimicrobial dilution and disk susceptibility testing of infrequently isolated or fastidious bacteria: M45 (3rd edition). Clinical and Laboratory Standards Institute.

Diemert, D. J. (2006). Prevention and Self-Treatment of Traveler's Diarrhea. Clinical Microbiology Reviews, 19(3), 583–594. https://doi.org/10.1128/CMR.00052-05

DiRita, V. J., Parsot, C., Jander, G., & Mekalanos, J. J. (1991). Regulatory cascade controls virulence in Vibrio cholerae. Proceedings of the National Academy of Sciences, 88(12), 5403–5407. https://doi.org/10.1073/pnas.88.12.5403

Dutta, D., Kaushik, A., Kumar, D., & Bag, S. (2021). Foodborne Pathogenic Vibrios: Antimicrobial Resistance. Frontiers in Microbiology, 12, 638331. https://doi.org/10.3389/fmicb.2021.638331

Elhadi, N., Radu, S., Chen, C.-H., & Nishibuchi, M. (2004). Prevalence of Potentially Pathogenic Vibrio Species in the Seafood Marketed in Malaysia. Journal of Food Protection, 67(7), 1469–1475. https://doi.org/10.4315/0362-028X-67.7.1469

Elmahdi, S., DaSilva, L. V., & Parveen, S. (2016). Antibiotic resistance of Vibrio parahaemolyticus and Vibrio vulnificus in various countries: A review. Food Microbiology, 57, 128–134. https://doi.org/10.1016/j.fm.2016.02.008

Fang, G.-Y., Liu, X.-Q., Mu, X.-J., Huang, B.-W., & Jiang, Y.-J. (2023). Distinct increase in antimicrobial resistance genes among Vibrio parahaemolyticus in recent decades worldwide. Chemosphere, 340, 139905. https://doi.org/10.1016/j.chemosphere.2023.139905

FAO. (2024). Antimicrobial Resistance. What Is It? https://www.fao.org/antimicrobial-resistance/background/what-is-it/en

Fri, J., Ndip, R. N., Njom, H. A., & Clarke, A. M. (2018). Antibiotic Susceptibility of Non-Cholera Vibrios Isolated from Farmed and Wild Marine Fish (Argyrosomus japonicus), Implications for Public Health. Microbial Drug Resistance, 24(9), 1296–1304. https://doi.org/10.1089/mdr.2017.0276

Gould, K. (2016). Antibiotics: From prehistory to the present day. Journal of Antimicrobial Chemotherapy, 71(3), 572–575. https://doi.org/10.1093/jac/dkv484

Halder, M., Saha, S., Mookerjee, S., & Palit, A. (2022). Exploring the dynamics of toxigenic environmental

Vibrio mimicus and its comparative analysis with Vibrio cholerae of the southern Gangetic delta. Archives of Microbiology, 204(7), 420. https://doi.org/10.1007/s00203-022-03028-z

Ham, H., & Orth, K. (2012). The role of type III secretion System 2 in Vibrio parahaemolyticus pathogenicity. Journal of Microbiology, 50(5), 719–725. https://doi.org/10.1007/s12275-012-2550-2

Helena Rebouças, R., Viana De Sousa, O., Sousa Lima, A., Roger Vasconcelos, F., De Carvalho, P. B., & Dos Fernandes Vieira, R. H. S. (2011). Antimicrobial resistance profile of Vibrio species isolated from marine shrimp farming environments (Litopenaeus vannamei) at Ceará, Brazil. Environmental Research, 111(1), 21–24. https://doi.org/10.1016/j.envres.2010.09.012

Hillis, D. M., & Bull, J. J. (1993). An Empirical Test of Bootstrapping as a Method for Assessing Confidence in Phylogenetic Analysis. Systematic Biology, 42(2), 182–192. https://doi.org/10.1093/sysbio/42.2.182

Honda, T., & Iida, T. (1993). The pathogenicity of Vibrio parahaemolyticus and the role of the thermostable direct haemolysin and related haemolysins: Reviews in Medical Microbiology, 4(2), 106–113. https://doi.org/10.1097/00013542-199304000-00006

Honda, T., Ni, Y., Miwatani, T., Adachi, T., & Kim, J. (1992). The thermostable direct hemolysin of Vibrio parahaemolyticus is a pore-forming toxin. Canadian Journal of Microbiology, 38(11), 1175–1180. https://doi.org/10.1139/m92-192

Hu, Y., Huang, X., Guo, L., Shen, Z., Lv, L., Li, F., Zhou, Z., & Zhang, D. (2021). Rapid and Visual Detection of Vibrio parahaemolyticus in Aquatic Foods Using bla CARB-17 Gene-Based Loop-Mediated Isothermal Amplification with Lateral Flow Dipstick (LAMP-LFD). Journal of Microbiology and Biotechnology, 31(12), 1672–1683. https://doi.org/10.4014/jmb.2107.07022

Jana, S., & Deb, J. K. (2006). Molecular understanding of aminoglycoside action and resistance. Applied Microbiology and Biotechnology, 70(2), 140–150. https://doi.org/10.1007/s00253-005-0279-0

Jones, J. L., Lüdeke, C. H. M., Bowers, J. C., Garrett, N., Fischer, M., Parsons, M. B., Bopp, C. A., & DePaola, A. (2012). Biochemical, Serological, and Virulence Characterization of Clinical and Oyster Vibrio parahaemolyticus Isolates. Journal of Clinical Microbiology, 50(7), 2343–2352. https://doi.org/10.1128/JCM.00196-12

Kang, C.-H., Shin, Y., Jang, S., Yu, H., Kim, S., An, S., Park, K., & So, J.-S. (2017). Characterization of Vibrio parahaemolyticus isolated from oysters in Korea: Resistance to various antibiotics and prevalence of virulence genes. Marine Pollution Bulletin, 118(1–2), 261–266. https://doi.org/10.1016/j.marpolbul.2017.02.070

Kim, Y. B., Okuda, J., Matsumoto, C., Takahashi, N., Hashimoto, S., & Nishibuchi, M. (1999a). Identification of Vibrio parahaemolyticus Strains at the Species Level by PCR Targeted to the toxR Gene. Journal of Clinical Microbiology, 37(4), 1173–1177. https://doi.org/10.1128/JCM.37.4.1173-1177.1999

Kim, Y. B., Okuda, J., Matsumoto, C., Takahashi, N., Hashimoto, S., & Nishibuchi, M. (1999b). Identification of Vibrio parahaemolyticus Strains at the Species Level by PCR Targeted to the toxR Gene. Journal of Clinical Microbiology, 37(4), 1173–1177. https://doi.org/10.1128/JCM.37.4.1173-1177.1999

Kishishita, M., Matsuoka, N., Kumagai, K., Yamasaki, S., Takeda, Y., & Nishibuchi, M. (1992). Sequence variation in the thermostable direct hemolysin-related hemolysin (trh) gene of Vibrio parahaemolyticus. Applied and Environmental Microbiology, 58(8), 2449–2457. https://doi.org/10.1128/aem.58.8.2449-2457.1992

Laganà, P., Caruso, G., Minutoli, E., Zaccone, R., & Santi, D. (2011). Susceptibility to antibiotics of Vibrio spp. And Photobacterium damsela ssp. Piscicida strains isolated from Italian aquaculture farms. The New Microbiologica, 34(1), 53–63.

Letchumanan, V., Chan, K.-G., & Lee, L.-H. (2014). Vibrio parahaemolyticus: A review on the pathogenesis, prevalence, and advance molecular identification techniques. Frontiers in Microbiology, 5. https://doi.org/10.3389/fmicb.2014.00705

Li, R., Chiou, J., Chan, E. W.-C., & Chen, S. (2016). A Novel PCR-Based Approach for Accurate Identification of Vibrio parahaemolyticus. Frontiers in Microbiology, 7. https://doi.org/10.3389/fmicb.2016.00044

Lin, Z., Kumagai, K., Baba, K., Mekalanos, J. J., & Nishibuchi, M. (1993). Vibrio parahaemolyticus has a homolog of the Vibrio cholerae toxRS operon that mediates environmentally induced regulation of the thermostable direct hemolysin gene.

Journal of Bacteriology, 175(12), 3844–3855. https://doi.org/10.1128/jb.175.12.3844-3855.1993

Lopatek, M., Wieczorek, K., & Osek, J. (2018). Antimicrobial Resistance, Virulence Factors, and Genetic Profiles of Vibrio parahaemolyticus from Seafood. Applied and Environmental Microbiology, 84(16), e00537-18. https://doi.org/10.1128/AEM.00537-18

Lulijwa, R., Rupia, E. J., & Alfaro, A. C. (2020). Antibiotic use in aquaculture, policies and regulation, health and environmental risks: A review of the top 15 major producers. Reviews in Aquaculture, 12(2), 640–663. https://doi.org/10.1111/raq.12344

Magiorakos, A.-P., Srinivasan, A., Carey, R. B., Carmeli, Y., Falagas, M. E., Giske, C. G., Harbarth, S., Hindler, J. F., Kahlmeter, G., Olsson-Liljequist, B., Paterson, D. L., Rice, L. B., Stelling, J., Struelens, M. J., Vatopoulos, A., Weber, J. T., & Monnet, D. L. (2012). Multidrug-resistant, extensively drug-resistant and pandrug-resistant bacteria: An international expert proposal for interim standard definitions for acquired resistance. Clinical Microbiology and Infection, 18(3), 268–281. https://doi.org/10.1111/j.1469-0691.2011.03570.x

Miller, V. L., & Mekalanos, J. J. (1988). A novel suicide vector and its use in construction of insertion mutations: Osmoregulation of outer membrane proteins and virulence determinants in Vibrio cholerae requires toxR. Journal of Bacteriology, 170(6), 2575–2583. https://doi.org/10.1128/jb.170.6.2575-2583.1988

Montieri, S., Suffredini, E., Ciccozzi, M., & Croci, L. (2010a). Phylogenetic and evolutionary analysis of Vibrio parahaemolyticus and Vibrio alginolyticus isolates based on toxR gene sequence. The New Microbiologica, 33(4), 359–372.

Montieri, S., Suffredini, E., Ciccozzi, M., & Croci, L. (2010b). Phylogenetic and evolutionary analysis of Vibrio parahaemolyticus and Vibrio alginolyticus isolates based on toxR gene sequence. The New Microbiologica, 33(4), 359–372.

Okamoto, A., Andreatti Filho, R., Rocha, T., Menconi, A., & Marietto-Gonçalves, G. (2009). Detection and transfer of antimicrobial resistance gene integron in Salmonella Enteritidis derived from avian material. Revista Brasileira de Ciência Avícola, 11(3), 195–201. https://doi.org/10.1590/S1516-635X2009000300009

Ozaktas, T., Taskin, B., & Gozen, A. G. (2012). High level multiple antibiotic resistance among fish surface associated bacterial populations in non-aquaculture freshwater environment. Water Research, 46(19), 6382–6390. https://doi.org/10.1016/j.watres.2012.09.010

Parthasarathy, S., Das, S. C., Kumar, A., Chowdhury, G., Miyoshi, S.-I., Dutta, S., & Mukhopadhyay, A. K. (2021). Molecular characterization and antibiotic resistance of Vibrio parahaemolyticus from Indian oyster and their probable implication in food chain. World Journal of Microbiology and Biotechnology, 37(8), 145. https://doi.org/10.1007/s11274-021-03113-3

Sawabe, T., Kita-Tsukamoto, K., & Thompson, F. L. (2007). Inferring the Evolutionary History of Vibrios by Means of Multilocus Sequence Analysis. Journal of Bacteriology, 189(21), 7932–7936. https://doi.org/10.1128/JB.00693-07

SEAFDEC. (2022). Fisheries Country Profile: Philippines. Southeast Asian Fisheries Development Center. http://www.seafdec.org/fisheries-country-profile-philippines/

Sechi, L. A., Dupre, I., Deriu, A., Fadda, G., & Zanetti, S. (2000). Distribution of Vibrio cholerae virulence genes among different Vibrio species isolated in Sardinia, Italy. Journal of Applied Microbiology, 88(3), 475–481. https://doi.org/10.1046/j.1365-2672.2000.00982.x

Siddique, A. B., Moniruzzaman, M., Ali, S., Dewan, Md. N., Islam, M. R., Islam, Md. S., Amin, M. B., Mondal, D., Parvez, A. K., & Mahmud, Z. H. (2021). Characterization of Pathogenic Vibrio parahaemolyticus Isolated From Fish Aquaculture of the Southwest Coastal Area of Bangladesh. Frontiers in Microbiology, 12, 635539. https://doi.org/10.3389/fmicb.2021.635539

Singh, N. S., Singhal, N., & Virdi, J. S. (2018). Genetic Environment of blaTEM-1, blaCTX-M-15, blaCMY-42 and Characterization of Integrons of Escherichia coli Isolated From an Indian Urban Aquatic Environment. Frontiers in Microbiology, 9, 382. https://doi.org/10.3389/fmicb.2018.00382

Song, G. G., Cho, H., Kim, Y., Jang, B., Lee, M., & Park, K. T. (2024). Whole-Genome Sequencing-based Antimicrobial Resistance and Genetic Profile Analysis of Vibrio parahaemolyticus Isolated from Seafood in Korea. Journal of Food Hygiene and Safety, 39(3), 231–238. https://doi.org/10.13103/JFHS.2024.39.3.231

Su, Y.-C., & Liu, C. (2007). Vibrio parahaemolyticus: A concern of seafood safety. Food Microbiology,

24(6), 549–558. https://doi.org/10.1016/j.fm.2007.01.005

Sundin, G. W. (2000). Examination of base pair variants of the strA-strB streptomycin resistance genes from bacterial pathogens of humans, animals and plants. Journal of Antimicrobial Chemotherapy, 46(5), 848–849. https://doi.org/10.1093/jac/46.5.848

Szczepanowski, R., Linke, B., Krahn, I., Gartemann, K.-H., Gützkow, T., Eichler, W., Pühler, A., & Schlüter, A. (2009). Detection of 140 clinically relevant antibiotic-resistance genes in the plasmid metagenome of wastewater treatment plant bacteria showing reduced susceptibility to selected antibiotics. Microbiology, 155(7), 2306–2319. https://doi.org/10.1099/mic.0.028233-0

Tabo, N. A., Ramirez, V. B., Tabo, H. A., & Gloriani, N. G. (2015). Occurrence and antimicrobial resistance of pathogenic vibrios isolated from green mussel, Perna viridis L. 1758 in Bacoor Bay, Cavite, Philippines. Acta Medica Philippina, 49(4).

Tada, J., Ohashi, T., Nishimura, N., Shirasaki, Y., Ozaki, H., Fukushima, S., Takano, J., Nishibuchi, M., & Takeda, Y. (1992). Detection of the thermostable direct hemolysin gene (tdh) and the thermostable direct hemolysin-related hemolysin gene (trh) of Vibrio parahaemolyticus by polymerase chain reaction. Molecular and Cellular Probes, 6(6), 477–487. https://doi.org/10.1016/0890-8508(92)90044-X

Tan, C. W., Rukayadi, Y., Hasan, H., Thung, T. Y., Lee, E., Rollon, W. D., Hara, H., Kayali, A. Y., Nishibuchi, M., & Radu, S. (2020). Prevalence and antibiotic resistance patterns of Vibrio parahaemolyticus isolated from different types of seafood in Selangor, Malaysia. Saudi Journal of Biological Sciences, 27(6), 1602–1608. https://doi.org/10.1016/j.sjbs.2020.01.002

Tian, C., Yuan, M., Tao, Q., Xu, T., Liu, J., Huang, Z., Wu, Q., Pan, Y., Zhao, Y., & Zhang, Z. (2023). Discovery of Novel Resistance Mechanisms of Vibrio parahaemolyticus Biofilm against Aminoglycoside Antibiotics. Antibiotics, 12(4), 638. https://doi.org/10.3390/antibiotics12040638

Wang, J., Zhan, Y., Sun, H., Fu, X., Kong, Q., Zhu, C., & Mou, H. (2022). Regulation of Virulence Factors Expression During the Intestinal Colonization of Vibrio parahaemolyticus. Foodborne Pathogens and Disease, 19(3), 169–178. https://doi.org/10.1089/fpd.2021.0057

Wang, X., Zhang, H., Yu, S., Li, D., Gillings, M. R., Ren, H., Mao, D., Guo, J., & Luo, Y. (2024). Inter-plasmid transfer of antibiotic resistance genes accelerates antibiotic resistance in bacterial pathogens. The ISME Journal, 18(1), wrad032. https://doi.org/10.1093/ismejo/wrad032

Yan, W., Ji, L., Dong, F., Chen, L., Yuan, R., & Zhang, P. (2024). Antimicrobial resistance and genomic analysis of Vibrio parahaemolyticus isolates from foodborne outbreaks, Huzhou, China, 2019–2023. Frontiers in Microbiology, 15, 1439522. https://doi.org/10.3389/fmicb.2024.1439522

Zhang, F., Zhang, J., Lin, G., Chen, X., Huang, H., Xu, C., & Chi, H. (2024). Antibiotic Resistance and Genetic Profiles of Vibrio parahaemolyticus Isolated from Farmed Pacific White Shrimp (Litopenaeus vannamei) in Ningde Regions. Microorganisms, 12(1), 152. https://doi.org/10.3390/microorganisms12010152

Zhang, Z., Lou, Y., Du, S., Xiao, L., Niu, B., Pan, Y., & Zhao, Y. (2017). Prevalence of Vibrio parahaemolyticus in seafood products from hypermarkets in Shanghai: Prevalence of Vibrio parahaemolyticus in Shanghai markets. Journal of the Science of Food and Agriculture, 97(2), 705–710. https://doi.org/10.1002/jsfa.7715

Zhang, Z., Zhang, Q., Wang, T., Xu, N., Lu, T., Hong, W., Penuelas, J., Gillings, M., Wang, M., Gao, W., & Qian, H. (2022). Assessment of global health risk of antibiotic resistance genes. Nature Communications, 13(1), 1553. https://doi.org/10.1038/s41467-022-29283-8

Disclaimer/Publisher's Note: The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of CMUJS and/or the editor(s). CMUJS and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.

CMU Journal of Science
The Official Scientific Journal of Central Mindanao University
ISSN Print: 0116-7847 js.cmu.edu.ph ISSN Online: 2704-3703

Research Article

Antimicrobial Resistance and Molecular Identification of *Vibrio* spp. in Shellfish at Major Public Wet Markets in Bukidnon, Philippines.

Matilda Grace Cempron1*, Zeus Elumba1, Johndel Remon1, Joliesa Mae Toledo1, Reggie Dela Cruz1

1Molecular Biology and Biotechnology, Genetics, and Microbiology Division, Institute of Biological Sciences, Central Mindanao University, University Town, Musuan, Maramag, Bukidnon, Philippines, 8714; matildagracecempron@gmail.com; zeuselumba@gmail.com; jdremon46@gmail.com; joliesamaetoledo@gmail.com; rydelacruz@cmu.edu.ph

Citation: Cempron, M. G., Elumba, Z., Remon, J., Toledo, J. M., & Dela Cruz, R. (2026). Antimicrobial Resistance and Molecular Identification of Vibrio spp. in Shellfish at Major Public Wet Markets in Bukidnon, Philippines. CMU Journal of Science, 30(1), 107.

Academic Editor: Dr. Frolan Aya

Received: Dec. 12, 2025
Revised: June 28, 2026
Accepted: June 28, 2026
Published: July 2, 2026

Copyright: © 2024 by the authors. Submitted for possible open access publication under the terms and conditions of the Creative Commons Attribution (CC BY) license (https://creativecommons.org/licenses/by/4.0/).

A B S T R A C T.

Vibrio species are particularly pathogenic and pose significant public health risks when shellfish become contaminated from aquatic ecosystem. This study assessed the occurrence, molecular identification, and antimicrobial resistance of *Vibrio* species isolated from mud clams, mud crabs, and white leg shrimp sold in three public markets in Bukidnon, Philippines. A high occurrence (55%) of these bacteria was observed across all locations. Molecular identification of fifteen bacterial isolates was performed using 16s rRNA gene sequencing followed by BLAST analysis against public databases. The results revealed the closes similarity to *V. alginolyticus* (5 isolates), *Vibrio* sp. (3 isolates), *V. furnissii* (2 isolates), and *V. parahaemolyticus* (5 isolates). Maramag public market has sample occurrence of 44.4% (4), Malaybalay 55.5% (5), and Valencia 66.6% (6). Accorss samples, the mud clam exhibited the highest occurrence rate of 88.8%, followed by shrimp at 33.3%, and mud crab at 30%. Antimicrobial susceptibility testing through disk diffusion method, following standardized inoculation, disc placement, incubation, and zone reading procedures of fifteen isolates, among them, 100% were resistance to ampicillin and 60% to cefotaxime, with 66% exhibiting multidrug resistance. The multidrug-resistant phenotype involved resistance to multiple antibiotic classes, including beta-lactams, macrolides, cephalosporin, and fluroquinolones. These findings point the presence of multi-drug resistant *Vibrio* spp., suggesting potential food safety risks and underscoring the need for ongoing monitoring and management to mitigate *Vibrio* related health threats in the region.The abstract should have a brief and factual presentation of the research purpose, major results, and main conclusion and should be presented separately. Citing references in the abstract, as well as mentioning non-standard or uncommon abbreviations must be avoided. It is imperative that are not supported by the main text or exaggerating the primary conclusions.

Keywords: Vibrio, Antimicrobial Resistance, Public Market

INTRODUCTION

Vibrio species are associated with severe vibriosis in both marine aquaculture and humans, with a history of seafood cosumption being a major risk factor for infection. It threatens human health, causing considerable illness, gastrointestinal disease, sepsis, and mortality worldwide (El-Zamkan et al., 2023; Osunla & Okoh, 2017). This species also infects economically important aquatic animals such as fish, shrimp, and shellfish (Cai et al., 2024; George et al., 2005; Norfolk et al., 2023). It causes acute hepatopancreatic necrosis syndrome (AHPNS), larval and juvenile mortality in seafood (Gómez-León et al., 2005; Yin et al., 2022).

Vibrio harbor key virulence factors. The ToxR regulon is a hierarchical regulatory system that controls the expression of significant virulence genes, cholera toxin (CT), and toxin-coregulated pilus (TCP) (J. Lee, 2023). The ctx genes (ctxA and ctxB) encode cholera toxin (CTX), a significant virulence factor linked to V. cholerae O1 and O139 strains (Potasman et al., 2002). Toxin-coregulated pilus (TcpP), a regulatory protein, positively modulates the expression of virulence genes in V. cholerae, including CTX and colonization factors like TCP (Häse & Mekalanos, 1998). TcpP is vital for V. cholerae infection by enhancing the expression of critical virulence genes (D. Lee et al., 2023). Virulence factors are crucial for pathogenic bacteria to evade host immune responses (Beceiro et al., 2013).

Antibiotics remain the most common treatment for vibriosis in aquaculture animals and in human infections. Effective antibiotics against Vibrio infections include tetracycline, quinolones, trimethoprim, potentiated sulfonamides, oxolinic acid, and sarafloxacin (Laganà et al., 2011; Yano et al., 2014). However, large quantities of antibiotics are administered in aquaculture, which contributes significantly to the development of antimicrobial resistance (AMR) (Nikaido, 2009).

Additionally, resistance determinants often reside in plasmids that can be transferred to other bacterial species through horizontal gene transfer mechanisms (Tao et al., 2022). Thus, AMR could spread across bacterial populations. Reports on Vibrio alginolyticus have been resistant to cephalotin, amikacin, cephotaxime, pefloxacin, ampicillin, and vancomycin (Kang et al., 2016; Soyer-Gobillard, 2017).

The European Food Safety Authority (2024) emphasizes the importance of identifying *Vibrio* species in seafood, noting that climate change-driven increases in sea surface temperatures promote their proliferation. Consequently, these bacteria post significant health risks, and warrant accurate monitoring and control in seafood production. Rising surface water temperatures resulting from global warming are driving worldwide increase in *Vibrio* outbreaks linked to contaminated seafoood (Onohuean et al., 2022; Vezzulli et al., 2015).

Public markets play a significant role in the dissemination and potential transmission of *Vibrio* species, as they serve as central hubs for the sale and handling of shellfish and other fresh produce, often under conditions or cross-contamination that can facilitate the spread of pathogens (Teh et al., 2020). Contamination of seafood products can occur during animal rearing, preparation, transport, and through food handlers working in unsanitary environments (WHO, 2019). Several studies in the Philippines have revealed *Vibrio* contamination in green mussels (Perna viridis) from Bacoor Bay, Cavite (Tabo et al., 2015). *Vibrio* spp. in tilapia from Pampanga (Aquino, 2022). Vibrio harveyi-like bacteria linked to fin rot in farmed milkfish fingerlings (Estante-Superio et al., 2021). A recently study also detected *Vibio* spp. in retail shrimp from General Santos City and Sarangani Province (Danao & Rallos, 2025).

However, there is limited data on the occurrence and contamination levels of *Vibrio* in seafood sold at wet markets across Mindanao, the country's second-largest island. Bukidnon, a landlocked province within Mindanao, relies heavily on wet markets for its seafood supply, yet there remain no specific studies addressing *Vibrio* contamination in these products. National-level monitoring of *Vibrio* prevalence in the Philippines' seafood is currently insufficient, highlighting the urgent need for comprehensive surveillance programs to

evaluate and mitigate food safety and public health risks. Sustained monitoring of *Vibrio* spp. and sustain monitoring of AMR *Vibrio* spp. in seawater, shellfish, and market environments is essential for preventing future outbreaks and safeguarding both consumer and ecosystem health.

METHODOLOGY

2.2 Collection of Shellfish Samples

The samples were aseptically purchased from the major public markets of Malaybalay City, Valencia City, and Maramag, Bukidnon (Figure 1). The shellfish with three samples from each market are mud clams (*Geloina striata Linne*), mud crabs (*Scylla* spp.), and white leg shrimp (*Litopenaeus vannamei*). The composite samples consist of 250 g of each seafood type. These samples were randomly collected aseptically from each stall, with three replicates of each sample per market, and placed in sterile plastic bags. After purchase, samples were transported to the Tuklas Lunas Development Center laboratory, Central Mindanao University on ice packs in cooler boxes within two hours of collection.

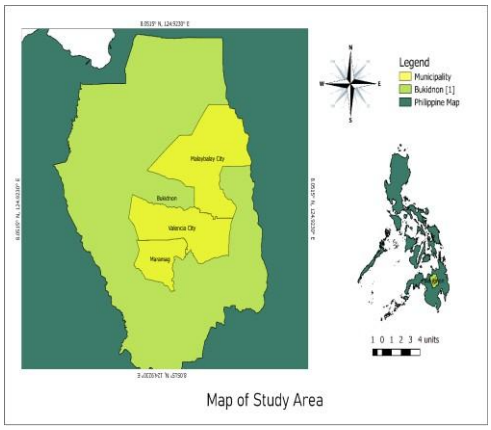


Figure 1. Location of sampling sites/public markets in the Province of Bukidnon.

2.3 Sample Processing, Isolation, and Purification of Isolates

Sample preparation was conducted according to the Bacteriological Analytical Manual guidelines (FDA, 2022). Each 25 g sample was added to 225 mL of alkaline peptone water (APW) (Condalab, Madrid, Spain) and homogenized using an immersion blender. The APW samples were transferred into Erlenmeyer flasks and incubated at 37°C for 24 hours.

The enrich culture in APW was serially diluted up to 10^5 in test tubes containing 9 mL saline solution (Himedia, India). Each diluent (100 µL) was spread onto Thiosulfate-citrate-bile salts-sucrose (TCBS) agar plates (Himedia, India). After 24 hours of incubation at 37°C, the presumptive *Vibrio* colonies measuring 2–4 mm in diameter, yellow with opaque centers and translucent edges, were identified. These colonies were then sub-cultured on TCBS agar plates using the streak plate method to obtain pure isolates.

2.4 Antimicrobial Susceptibility Testing

Vibrio isolates were subjected to antimicrobial susceptibility testing. The antibiogram of each of the *Vibrio* isolates was determined through the standard disk diffusion assay (CLSI, 2012). A total of eight (8) antibacterial agents (Bioanalyse, Turkey) namely: ampicillin (AP) 10 µg, azithromycin (ATH) 15 µg, cefotaxime (CTX) 30 µg, chloramphenicol (C) 30 µg, sulphonamides 250 µg, tetracycline (TET) 30 µg, trimethoprim-sulfamethoxazole (TM-SMX) 5 µg, meropenem (MEM) 10 µg, and ciprofloxacin (CIP) 5 µg were used. These antibiotics were selected based on their frequent use in clinical practices and according to the Clinical and Laboratory Standards Institute (CLSI) M45 and M100 guidelines for *Vibrio*.

A direct colony suspension was prepared by suspending bacterial colonies in a 0.85% NaCl solution and adjusting the turbidity to a 0.5 McFarland standard. Using a sterile cotton swab, the standardized inoculum was evenly swabbed onto a Mueller-Hinton agar (MHA) plate (Himedia, India). After the placement of the antibiotic discs, the placement was allowed to dry for 5–10 minutes before incubation, permitting proper disc contract with the agar; antibiotic diffusion occurred during incubation. The Petri dish used was 90 mm in diameter. The distance between the antibiotic discs was 20-24 mm edge to edge, and the plates were incubated at 35°C for 16–20 hours. The zone of inhibition for each antibiotic was measured in millimeters with a ruler. The established zone of inhibition (ZOI) breakpoints for each antibiotic against *Vibrio* spp., set by the Clinical and Laboratory Standards Institute (CLSI) M45 and M100 guidelines, were used to classify the isolates as susceptible, intermediate, or resistant.

2.5 Determination of Multiple Antibiotic Resistance Index (MARI)

The MARI was calculated and interpreted for each isolate, sample type, and sampling area as recommended.

The isolates with a MARI of ≥ 0.2 indicate that they originated from an environment with high antibiotic exposure. The MARI was calculated using a formula adopted from Abioye et al. (2023) as shown below:

MARI from an isolate = a/b

Where a = number of antibiotics an isolate exhibited resistance against, and b = the total number of antibiotics tested against the isolate.

2.6 Sequencing and Data Analysis

The *Vibrio* isolates in glycerol stock were sent to Macrogen, Incorporated, located at 908 World Meridian Venture Center, No.60-24 Gasan Dong, Geumchun-gu, Seoul, South Korea. for sequencing. MEGA 5.05 software was used to assemble the sequences. The isolates were sequenced for 16S rRNA, F(5′-AGAGTTTGATCCTGGCTCAG-3′), R(5′-GGTTACCTTGTTACGACTT-3′) for identification. Subsequently, these sequences were compared to entries in GenBank using the BLAST search engine and submitted to the NCBI (http://www.ncbi.nlm.gov/blast/).

RESULTS AND DISCUSSION

3.1 Occurrence of *Vibrio* Isolates

Molecular identification of twenty-seven bacterial isolates was performed using *16S rRNA* gene sequencing followed by BLAST analysis against public databases. The results revealed the closest similarity to *Vibrio alginolyticus* (5/27), *Vibrio sp*. (3/27), *Vibrio furnissii* (2/27), and *Vibrio parahaemolyticus* (5/27). The occurrence of *Vibrio* species from samples is parallel to the study of Alavandi (2006), where *Vibrio* species have also been recovered from seafood sources such as green mussels, indicating the broad distribution of these bacteria in marine food products. Additionally, *Vibrio* species, including *V. cholerae*, *V. harveyi*, *Vibrio furnissii*, and *V. fluvialis*, have been from blue crabs (*Callinectes sapidus*), an important commercially harvested crustacean by Omogbai (2016). Gómez-León (2005) isolated *V. alginolyticus* and *V. splendidus* biovar II from moribund carpet shell clam larvae, implicating these species in aquaculture disease outbreaks. Furthermore, occurrences of *Vibrio* species have been documented in cultured white leg shrimp (*Litopenaeus vannamei*), which is a major species in shrimp aquaculture (Danao & Rallos, 2025).

The use of Thiosulfate Citrate Bile Salts Sucrose (TCBS) agar was crucial in isolating *Vibrio* species. Glackin (2024) demonstrated the effectiveness of combining TCBS agar with CHROMagar for isolating *Vibrio* spp. from environmental samples. Their method involved directly plating water and sediment onto TCBS agar, incubating the plates, and counting the colonies, followed by molecular confirmation. Authoritative guidelines from the U.S. Centers for Disease Control and Prevention (CDC, 2024) recommend TCBS agar as the preferred selective medium for isolating *V. cholerae* from both fecal and environmental samples. When combined with enrichment in alkaline peptone water, TCBS agar enhances recovery rates and facilitates reliable identification through its characteristic colony appearance.

The reliability of TCBS agar is further supported by the earlier work of Uchiyama (2000), who successfully isolated multiple *Vibrio* species—including *V. alginolyticus*, *V. parahaemolyticus*, *V. vulnificus*, and *V. cholerae*—from various aquatic environments such as rivers, estuaries, and seawater. This confirms the medium's usefulness as a standard in aquatic microbiology for identifying and isolating *Vibrio* spp.. Tagliavia (2019) further support the essential role of TCBS agar in *Vibrio* isolation but recommend modifications to expand the recovery range of marine *Vibrio* species. These adjustments could improve the medium's selectivity and sensitivity, highlighting ongoing efforts to refine microbiological detection methods.

Vibrio species are important foodborne pathogens capable of causing gastrointestinal illness and, in some cases, severe extraintestinal infections. Although many *Vibrio* isolates remain susceptible to commonly used antibiotics, their occurrence in food and aquatic products remains a public health concern because infection may lead to serious outcomes, particularly among immunocompromised individuals or those with wound exposure (El-Zamkan et al., 2023). *Vibrio alginolyticus* is a naturally occurring marine bacterium and an emerging pathogen of both humans and animals; it is also recognized as a major cause of vibriosis in some settings. As an opportunistic pathogen, it is often associated with individuals with weakened immunity or open wounds, and its rapid progression and high mortality in severe infections make it clinically significant (Norfolk et al., 2023; Cai et al., 2024). Likewise, *Vibrio fluvialis*, which is commonly associated with coastal environments, has gained attention as an emerging pathogen because of its involvement in diarrheal outbreaks and occasional extraintestinal infections (Ramamurthy et al., 2014).

The increasing occurrence of *Vibrio* related infections worldwide may be linked, in part, to climate change and the associated rise in sea surface temperatures. Over the past century, sea surface temperature has increased by approximately 1°C, creating more favorable conditions for Vibrio growth, persistence, and pathogenicity. Warmer waters enhance bacterial culturability, growth, and virulence-related traits, while also influencing interactions with aquatic hosts and abiotic surfaces. In particular, ocean warming strengthens associations between *Vibrio* species and zooplankton,

which can serve as reservoirs that support bacterial survival and dissemination in marine ecosystems (Vezzulli et al., 2015). These ecological shifts highlight the broader impact of climate change on the epidemiology of Vibrio infections and underscore the need for interdisciplinary research to understand their transmission dynamics.

Recent evidence also shows that climate change is contributing to the spread of waterborne diseases caused by *Vibrio* species, especially in warm, low-salinity waters. Important pathogenic species such as *V. vulnificus*, *V. parahaemolyticus*, and *V. cholerae* are strongly influenced by environmental temperature, with their prevalence increasing as ocean conditions become warmer and more variable. Human cases and outbreaks have risen in regions previously considered low-risk, suggesting that *Vibrio* may serve as an indicator of climate-driven ecological change in marine environments. Given this pattern, addressing *Vibrio* associated risks requires integrated approaches that combine microbiology, genomics, epidemiology, climate science, and oceanography (Baker-Austin et al., 2017).

Table 1. Occurrence of Vibrio species in composite seafood samples collected from three Public Wet Markets in Bukidnon, Philippines.

Market	Sample (Composite)		
	Mud Clam N (%)	White leg shrimp, n (%)	Mud crab, n(%)
Malaybalay	2/3 (66.6%)	2/3 (66.6%)	1/3 (33.3%)
Valencia	3/3 (100%)	2/3 (66.6%)	1/3 (33.3%)
Maramag	3/3 (100%)	0/3 (%)	1/3 (33.3%)

3.2 Antibiogram of *Vibrio* Isolates

The antimicrobial resistance profile of *Vibrio* species isolates in this study reveals critical insight into both current susceptibility patterns and emerging resistance trends, emphasizing the urgent need for ongoing surveillance and targeted interventions. Fifteen *Vibrio* isolates are resistant to ampicillin but susceptible to chloramphenicol and tetracycline. For trimethoprim/sulfamethoxazole and meropenem, one (6.6%) shows intermediate resistance, while fourteen (93.3%) are susceptible. Regarding azithromycin resistance, five isolates (33.3%) are resistant, and ten (66.6%) are susceptible. For cefotaxime, nine (60%) are resistant, four (26.6%) are intermediate, and two (13.3%) are susceptible. For ciprofloxacin, two (13.3%) are resistant, five (13.3%) are intermediate, and eight (53.5%) are susceptible (Table 2). Additionally, ten (66%) isolates demonstrate a multiple-drug resistant (MDR) pattern.

Table 2. Antibiogram profile of fifteen *Vibrio* isolates

Antibiotic class	Subclass	Antibiotics	*Vibrio* isolates		
			Susceptible (n, %)	Intermediate (n, %)	Resitant (n, %)
Beta-lactam	Penicillin	Ampicillin	0	0	15 (100%)
	Carbapenims	Meropenem	14 (93.3%)	1 (6.6%)	0
	Cephems	Cefotaxime	2 (13.3%)	4 (26.6%)	9 (60%)
Macrolides		Azithromycin	10 (66.6%)	0	5 (33.3%)
Phenicol		Chloramphenicol	15 (100%)	0	0
Folate pathway inhibitors		Trimethoprim-sulfamethoxazole	14 (96.3%)	1 (3.7%)	0
Fluoroquinolones		Ciprofloxacin	11 (40.8%)	2 (7.4%)	2 (7.4%)
Tetracycline		Tetracycline	15 (100%)	0	0

Similar research on *Vibrio* species isolated from green mussels (*Perna viridis L.* 1758) in Bacoor Bay, Cavite, by Tabo (2015) showed resistance to various antibiotics such as ampicillin, nalidixic acid, tetracycline, and co-trimoxazole. Another study by Sun (2024) also reported strains of *Vibrio alginolyticus* isolated from seafood and freshwater sources in China exhibited resistance to multiple antibiotics, including beta-lactams, tetracyclines, and fosfomycin, which was linked to the presence of *blaCARB*, *tet*, and *fos* genes. From 2005 to 2007, Oh (2011) investigated *V. parahaemolyticus* isolates from farmed fish species such as olive flounder (*Paralichthys olivaceus*), black rockfish (*Sebastes schlegeli*), red sea bream (*Pagrus major*), and sea bass (*Lateolabrax japonicus*) and found these isolates to be resistant to ampicillin.

The findings of Hernandez-Robles (2016) further enrich the discussion by demonstrating that *Vibrio alginolyticus* strains isolated from oyster samples in a food market in Mexico City exhibited high levels of antimicrobial resistance. Specifically, over 90% of these strains were resistant to beta-lactam antibiotics, with resistance rates of 60% to cephalotin, 45% to amikacin, 16% to cefotaxime, and 10% to pefloxacin. Importantly, all isolates remained susceptible to ceftriaxone. These *V. alginolyticus* strains exhibited multidrug resistance, paralleling the patterns observed in other geographic regions like Hong Kong, US, and China reinforcing the global challenge posed by resistant *Vibrio* species in seafood sources. This data emphasizes the necessity for continuous antimicrobial resistance monitoring and the promotion of prudent antibiotic use in aquaculture and seafood handling to protect public health.

Including the findings of Kang (2016), *Vibrio alginolyticus* strains isolated from oysters in the West Sea coastal regions of Korea exhibited resistance to ampicillin, vancomycin, and cephalothin. All isolates also showed intermediate resistance to erythromycin and rifampin. Similarly, studies in the Eastern Adriatic Sea highlighted that *V. alginolyticus* isolates were more frequently found in the gills than on the skin of fish and demonstrated statistically significant high susceptibility to flumequine, chloramphenicol, and oxytetracycline (Damir et al., 2013). Furthermore, *Vibrio alginolyticus* strains isolated from mussels in Italy were reported to carry plasmid DNA, with all isolates resistant to ampicillin, carbenicillin, and streptomycin (Ripabelli et al., 2003). These results demonstrate the widespread occurrence of antimicrobial resistance in *V. alginolyticus* across diverse geographical regions and aquatic sources, highlighting the role of plasmids in the dissemination of resistance genes and the variability in susceptibility profiles that depend on the aquatic environment.

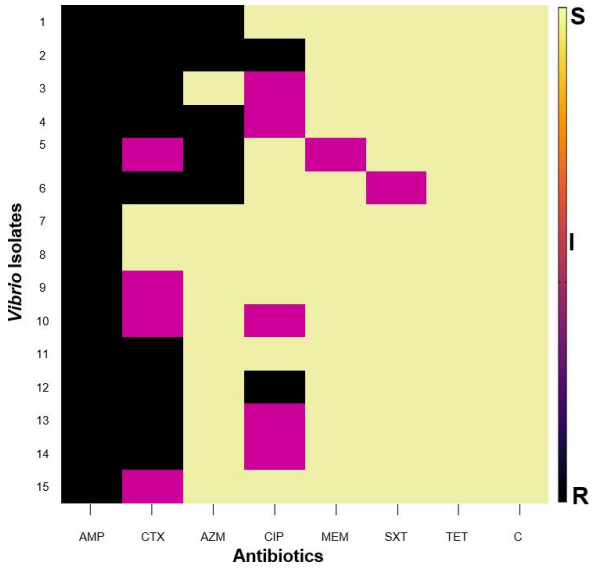


Figure 2. Heat map showing the antimicrobial resistance profile of the individual fifteen *Vibrio* species isolated from seafood samples. Antibiotics are abbreviated as follows: ampicillin (AMP), cefotaxime (CTX), azithromycin (AZM), ciprofloxacin (CIP), meropenem (MEM), trimethoprim/sulfamethoxazole (SXT), tetracycline (TET), and chloramphenicol (C).

3.3 Antimicrobial Resistance Phenotypes and Multiple Antibiotic Resistance Index (MARI) of *Vibrio* Species

Table 3. Multiple Antibiotic Resistance (MAR) Index of *Vibrio* isolates.

Resistant Phenotype	Number of Isolates	Number of antibiotic classes tested	MAR Index	Interpretation
AMP	5	6	0.1	Low-Risk
AMP, CTX	4	6	0.3	High-Risk
AMP, AZM	1	6	0.3	High-Risk
AMP, AZM, CTX	3	6	0.5	High-Risk
AMP, CTX, CIP	1	6	0.5	High-Risk
AMP, AZM, CTX, CIP	1	6	0.6	High-Risk

The *Vibrio* isolates display six resistance phenotypes (Table 3), while the MAR index ranges from 0.1 to 0.6, with isolates classified as "high risk" (MAR index ≥ 0.2) (Table 3). The Multiple Antibiotic Resistance (MAR) index analysis as described previously by Gxalo (2021), isolates from different public markets and shellfish sources reveals notable variations in antibiotic resistance profiles. Among the three municipalities studied, Valencia samples exhibited MAR index values ranging from 0.14 to 0.6, indicating a relatively higher level of antibiotic

exposure or selective pressure in this area. In contrast, Maramag samples showed a 0.1 MAR index. Malaybalay samples with values ranging from 0.1 to 0.5 MAR index.

Considering the MAR indices across various shellfish samples, mud clams showed a range of 0.1 to 0.6, which is slightly higher than the values observed in white leg shrimps and mud crabs, ranging from 0.1 to 0.5. This indicates that mud clams may be exposed to or accumulate higher levels of antibiotic-resistant bacteria, likely due to their habitat or feeding behaviors that increase contact with contaminated sediments or water. These findings highlight the variability of antibiotic resistance in *Vibrio* spp. or other bacterial isolates, depending on geographic location and sample source.

The presence of high MAR index values among *Vibrio* isolates indicates where antibiotics where greatly utilized (Gxalo, 2021). The predominant AMP, CTX resistance phenotype suggests significant resistance to β-lactam antibiotics, particularly ampicillin and cefotaxime. The highest MAR index (0.6) was linked to identified as *Vibrio* sp. is resistant to four antibiotics: AMP, AZM, CTX, and CIP. This multi-drug resistant profile is especially concerning, as it includes resistance to ciprofloxacin, a widely used fluoroquinolone and a critical drug for cholera treatment (Khan et al., 2015). Its resistance indicates emerging treatment challenges. Furthermore, isolates resistant to AMP, AZM, and MEM with MAR indices of 0.37 highlight the co-resistance trend, especially involving azithromycin (AZM), a first-line treatment for cholera. The detection of resistance to MEM (meropenem), a last-resort antibiotic, is concerning and warrants further investigation. Patients infected with meropenem-resistant organisms have higher risk of treatment failure and death compared with infections by susceptible strains (Judd, 2016).

Studies such as those conducted by Morgado (2024) and Adesiyan (2022) have reported similar ranges of Multiple Antibiotic Resistance (MAR) indices and comparable resistance profiles in *Vibrio* isolates. Morgado (2024) identified *Vibrio parahaemolyticus* isolates exhibiting MAR indices as high as 0.38, with predominant resistance to ampicillin and other β-lactam antibiotics, closely matching the frequent AMP, CTX resistance phenotype and the MAR index range of 0.25 to 0.50 observed in this study. Similarly, Adesiyan (2022) documented MAR indices ranging from 0.11 to 0.72 among *Vibrio* isolates sourced from freshwater environments, with a remarkable 97% of isolates categorized within the high-risk group (MAR ≥ 0.2).

Further supporting these observations, Haque (2012) revealed multidrug resistance in *Vibrio cholerae* isolates, with MAR indices reaching up to 1.0, exhibiting resistance to ampicillin, cefotaxime, azithromycin, and ciprofloxacin. This aligns with our detection of resistance phenotypes involving these antibiotics, including the alarming emergence of ciprofloxacin and meropenem resistant strains, signaling potentially significant challenges in treatment. In marine settings, Su (2022) found that approximately 72% of *Vibrio* isolates recovered from oriental hard clams were multi-drug resistant, with MAR values ranging between 0.18 and 0.31. The predominant resistance was noted against ampicillin and related β-lactams. Additionally, their study emphasized a correlation between co-resistance and environmental pressures such as heavy metal contamination, complementing our discussion on the influence of habitat and external factors on the antibiotic resistance profiles and MAR indices.

Moreover, Deng (2020) reported widespread multidrug resistance among Vibrio species, with over 64% of strains resistant to three or more antibiotic classes and MAR indices ranging from 0.00 to 0.60. A higher MAR index approaching 1 indicates a greater degree of antibiotic resistance, whereas a lower MAR index near 0 indicates little or no resistance (Isaiah, 2025). These data similarly highlight the presence of high-risk contamination sources and further bolster our argument regarding the public health implications posed by multidrug-resistant *Vibrio* strains and the critical need for ongoing MAR index monitoring across clinical and environmental isolates. Together, these studies provide strong and supportive evidence backing our observations of MAR index ranges (0.1–0.6), β-lactam resistance (AMP, CTX), the involvement of azithromycin and ciprofloxacin in multidrug resistance, and variability in resistance patterns based on geography and sample source. Multi-drug resistant Vibrio species are an increasing concern across aquatic environments, where they threaten aquaculture productivity and public health. This underscores the need for continued surveillance and targeted antibiotic stewardship programs, including routine resistance monitoring, responsible antimicrobial use in aquaculture, and strengthened biosecurity measures. These findings reaffirm the urgent necessity for establishing routine surveillance frameworks and prudent antibiotic use policies in aquaculture. Monitoring MAR indices offers a valuable epidemiological approach and assess the potential health risks associated with *Vibrio* sp. isolates from both clinical and environmental sources.

CONCLUSION

This study confirms that *Vibrio* isolates are highly present in the shellfish sold in Malaybalay, Valencia, and Maramag public markets in Bukidnon, Philippines, posing potential food safety risks. The findings underscore the importance of enhanced management practices to mitigate *Vibrio* associated health risks in the region.

Author Contributions: MGI Cempron – Sampling, data collection, laboratory work, and manuscript preparation. ZS Elumba – Conceptualization and editing. JMS Toledo, RY Dela Cruz – Reviewing of manuscript.

Funding: This research was funded by the Department of Science and Technology – Science Education Institute, Science and Technology Regional Alliance of Universities for National Development

Data Availability Statement: The authors declare the availability of data.

Acknowledgments: The author acknowledges the support of the Department of Science and Technology – Science Education Institute (DOST-SEI) through the STRAND scholarship. Tuklas Lunas Development Center,

Conflicts of Interest: The authors declare that there is no conflict of interest.

REFERENCES

1. Adesiyan, I. M., Bisi-Johnson, M. A., & Okoh, A. I. (2022). Incidence of antibiotic resistance genotypes of Vibrio species recovered from selected freshwaters in Southwest Nigeria. *Scientific Reports*, *12*(1), 18912. https://doi.org/10.1038/s41598-022-23479-0
2. Alavandi, S. V., Manoranjita, V., Vijayan, K. K., Kalaimani, N., & Santiago, T. C. (2006). Phenotypic and molecular typing of *Vibrio harveyi* isolates and their pathogenicity to tiger shrimp larvae. *Letters in Applied Microbiology*, *43*(5), 566–570. https://doi.org/10.1111/j.1472-765X.2006.01986.x
3. Aquino, Michelle Grace B., Dante M., and Reyes, Alvin T. (2022). Quantitative analysis of Vibrio spp. And environmental quality assessment of tilapia grow-out ponds in Minalin, Pampanga, Philippines. *Aquaculture, Aquarium, Conservation & Legislation Bioflux*, *16*(2), 1055–1068.
4. Beceiro, A., Tomás, M., & Bou, G. (2013). Antimicrobial Resistance and Virulence: A Successful or Deleterious Association in the Bacterial World? *Clinical Microbiology Reviews*, *26*(2), 185–230. https://doi.org/10.1128/CMR.00059-12
5. Cai, H., Yu, J., Li, Q., Zhang, Y., & Huang, L. (2024). Research Progress on Virulence Factors of *Vibrio alginolyticus*: A Key Pathogenic Bacteria of Sepsis. In N. Shaikh (Ed.), *Heat Illness and Critical Care*. IntechOpen. https://doi.org/10.5772/intechopen.108206
6. Damir, K., Irena, V. S., Damir, V., & Emin, T. (2013). Occurrence, characterization and antimicrobial susceptibility of Vibrio alginolyticus in the Eastern Adriatic Sea. *Marine Pollution Bulletin*, *75*(1–2), 46–52. https://doi.org/10.1016/j.marpolbul.2013.08.008
7. Danao, E. P., & Rallos, L. E. E. (2025). Prevalence and Antibiotic Resistance Patterns of Vibrio spp. In Assorted Retail Shrimp Products Sold in General Santos City and Sarangani Province. *Journal of Engineering, Environment, and Agriculture Research*, *4*(1), 59–80. https://doi.org/10.34002/jeear.v4i1.144
8. Deng, Y., Xu, L., Chen, H., Liu, S., Guo, Z., Cheng, C., Ma, H., & Feng, J. (2020). Prevalence, virulence genes, and antimicrobial resistance of Vibrio species isolated from diseased marine fish in South China. *Scientific Reports*, *10*(1), 14329. https://doi.org/10.1038/s41598-020-71288-0
9. El-Zamkan, M. A., Ahmed, A. S., Abdelhafeez, H. H., & Mohamed, H. M. A. (2023). Molecular characterization of Vibrio species isolated from dairy and water samples. *Scientific Reports*, *13*(1), 15368. https://doi.org/10.1038/s41598-023-42334-4
10. Estante-Superio, E. G., Pakingking, R. V., Corre, V. L., & Cruz-Lacierda, E. R. (2021). Vibrio harveyi-like bacteria associated with fin rot in farmed milkfish Chanos chanos (Forsskal) fingerlings in the Philippines. *Aquaculture*, *534*, 736259. https://doi.org/10.1016/j.aquaculture.2020.736259
11. George, M. R., John, K. R., Iyappan, T., & Jeyaseelan, M. J. P. (2005). Genetic heterogeneity among Vibrio alginolyticus isolated from shrimp farms by PCR fingerprinting. *Letters in Applied Microbiology*, *40*(5), 369–372. https://doi.org/10.1111/j.1472-765X.2005.01675.x
12. Glackin, C. C., Dupke, S., Chandra, T. S., Riedinger, D., & Labrenz, M. (2024). Combined TCBS and CHROMagar Analyses Allow for Basic Identification of Vibrio vulnificus within a 48 h Incubation Period in the Coastal Baltic Sea. *Microorganisms*, *12*(3), 614. https://doi.org/10.3390/microorganisms12030614
13. Gómez-León, J., Villamil, L., Lemos, M. L., Novoa, B., & Figueras, A. (2005). Isolation of *Vibrio alginolyticus* and *Vibrio splendidus* from Aquacultured Carpet Shell Clam (*Ruditapes decussatus*) Larvae Associated with Mass Mortalities. *Applied and Environmental Microbiology*, *71*(1), 98–104. https://doi.org/10.1128/AEM.71.1.98-104.2005
14. Haque, S. F., Ali, S.-Z., Tp, M., & Khan, A. U. (2012). Prevalence of plasmid mediated blaTEM-1 and blaCTX-M-15 type extended spectrum beta–

lactamases in patients with sepsis. *Asian Pacific Journal of Tropical Medicine*, *5*(2), 98–102. https://doi.org/10.1016/S1995-7645(12)60003-0

15. Häse, C. C., & Mekalanos, J. J. (1998). TcpP protein is a positive regulator of virulence gene expression in *Vibrio cholerae*. *Proceedings of the National Academy of Sciences*, *95*(2), 730–734. https://doi.org/10.1073/pnas.95.2.730
16. Kang, C.-H., Shin, Y., Jang, S., Jung, Y., & So, J.-S. (2016). Antimicrobial susceptibility of Vibrio alginolyticus isolated from oyster in Korea. *Environmental Science and Pollution Research*, *23*(20), 21106–21112. https://doi.org/10.1007/s11356-016-7426-2
17. Khan, W. A., Saha, D., Ahmed, S., Salam, M. A., & Bennish, M. L. (2015). Efficacy of Ciprofloxacin for Treatment of Cholera Associated with Diminished Susceptibility to Ciprofloxacin to Vibrio cholerae O1. *PloS One*, *10*(8), e0134921. https://doi.org/10.1371/journal.pone.0134921
18. Laganà, P., Caruso, G., Minutoli, E., Zaccone, R., & Santi, D. (2011). Susceptibility to antibiotics of Vibrio spp. And Photobacterium damsela ssp. Piscicida strains isolated from Italian aquaculture farms. *The New Microbiologica*, *34*(1), 53–63.
19. Lee, D., Choi, H., Son, S., Bae, J., Joo, J., Kim, D. W., & Kim, E. J. (2023). Expression of Cholera Toxin (CT) and the Toxin Co-Regulated Pilus (TCP) by Variants of ToxT in Vibrio cholerae Strains. *Toxins*, *15*(8), 507. https://doi.org/10.3390/toxins15080507
20. Lee, J. (2023). Exploring Sucrose Fermentation: Microorganisms, Biochemical Pathways, and Applications. *Fermentation Technology*, *12*(1), 1–1. https://doi.org/10.4172/2167-7972.23.12.166
21. Morgado, M. E., Brumfield, K. D., Chattopadhyay, S., Malayil, L., Alawode, T., Amokeodo, I., He, X., Huq, A., Colwell, R. R., & Sapkota, A. R. (2024). Antibiotic resistance trends among *Vibrio vulnificus* and *Vibrio parahaemolyticus* isolated from the Chesapeake Bay, Maryland: A longitudinal study. *Applied and Environmental Microbiology*, *90*(6), e00539-24. https://doi.org/10.1128/aem.00539-24
22. Nikaido, H. (2009). Multidrug resistance in bacteria. *Annual Review of Biochemistry*, *78*, 119–146. https://doi.org/10.1146/annurev.biochem.78.082907.145923
23. Norfolk, W. A., Shue, C., Henderson, W. M., Glinski, D. A., & Lipp, E. K. (2023). Vibrio alginolyticus growth kinetics and the metabolic effects of iron. *Microbiology Spectrum*, *11*(6), e0268023. https://doi.org/10.1128/spectrum.02680-23
24. Oh, E.-G., Son, K.-T., Yu, H., Lee, T.-S., Lee, H.-J., Shin, S., Kwon, J.-Y., Park, K., & Kim, J. (2011). Antimicrobial Resistance of Vibrio parahaemolyticus and Vibrio alginolyticus Strains Isolated from Farmed Fish in Korea from 2005 through 2007. *Journal of Food Protection*, *74*(3), 380–386. https://doi.org/10.4315/0362-028X.JFP-10-307
25. Omogbai Barry Aigbodion And ObichiCynthia Nnenji. (2016). Antimicrobial susceptibility patterns and plasmid profile of vibriospecies from processed and unprocesssed food grade crab. *Food and Applied Bioscience*, *4*, 6483. https://doi.org/10.14456/FABJ.2016.7
26. Onohuean, H., Agwu, E., & Nwodo, U. (2022). A Global Perspective of *Vibrio* Species and Associated Diseases: Three-Decade Meta-Synthesis of Research Advancement. *Environmental Health Insights*, *16*, 11786302221099406. https://doi.org/10.1177/11786302221099406
27. Osunla, C. A., & Okoh, A. I. (2017). Vibrio Pathogens: A Public Health Concern in Rural Water Resources in Sub-Saharan Africa. *International Journal of Environmental Research and Public Health*, *14*(10), 1188. https://doi.org/10.3390/ijerph14101188
28. Potasman, I., Paz, A., & Odeh, M. (2002). Infectious Outbreaks Associated with Bivalve Shellfish Consumption: A Worldwide Perspective. *Clinical Infectious Diseases*, *35*(8), 921–928. https://doi.org/10.1086/342330
29. Ripabelli, G., Sammarco, M. L., McLauchlin, J., & Fanelli, I. (2003). Molecular Characterisation and Antimicrobial Resistance of Vibrio vulnificus and Vibrio alginolyticus Isolated from Mussels (Mytilus galloprovincialis). *Systematic and Applied Microbiology*, *26*(1), 119–126. https://doi.org/10.1078/072320203322337407
30. Soyer-Gobillard, M.-O. (2017). Virulence factors and antimicrobial resistance in environmental strains of Vibrio alginolyticus. *International Microbiology*, *19*, 191–198. https://doi.org/10.2436/20.1501.01.277
31. Su, J., Zhang, Y., Hu, T., Ming, H., Xie, Y., Jin, Y., Shi, T., & Fan, J. (2022). Prevalence, antibiotic and heavy metal resistance of Vibrio spp. Isolated from the clam Meretrix meretrix at different ages in Geligang, Liaohe estuary in China. *Frontiers in Marine Science*, *9*, 1071371. https://doi.org/10.3389/fmars.2022.1071371
32. Sun, Y., Yan, Y., Yan, S., Li, F., Li, Y., Yan, L., Yang, D., Peng, Z., Yang, B., Sun, J., Xu, J., Dong, Y., & Bai, Y. (2024). Prevalence, antibiotic susceptibility, and genomic analysis of Vibrio alginolyticus isolated from seafood and freshwater products in China. *Frontiers in Microbiology*, *15*, 1381457. https://doi.org/10.3389/fmicb.2024.1381457
33. Tabo, N. A., Ramirez, V. B., Tabo, H. A. L., & Gloriani, N. G. (2015). Occurrence and Antimicrobial Resistance of Pathogenic Vibrios Isolated from Green Mussel, Perna

viridis L. 1758 in Bacoor Bay, Cavite, Philippines. *Acta Medica Philippina*, *49*(4). https://doi.org/10.47895/amp.v49i4.898

34. Tagliavia, M., Salamone, M., Bennici, C., Quatrini, P., & Cuttitta, A. (2019). A modified culture medium for improved isolation of marine vibrios. *MicrobiologyOpen*, *8*(9), e00835. https://doi.org/10.1002/mbo3.835
35. Tao, S., Chen, H., Li, N., Wang, T., & Liang, W. (2022). The Spread of Antibiotic Resistance Genes In Vivo Model. *Canadian Journal of Infectious Diseases and Medical Microbiology*, *2022*, 1–11. https://doi.org/10.1155/2022/3348695
36. Teh, T. R. D., Santos, J. A. P., & Cayetano, M. G. (2020). *Detection of Vibrioparahaemolyticus in fish samples from selected wet markets in Laguna, Philippines, using loop-mediated isothermal amplification (LAMP) and real-time polymerase chain reaction (qPCR)*. *13*.
37. Uchiyama, H. (2000). Distribution of vibrio species isolated from aquatic environments with TCBS agar. *Environmental Health and Preventive Medicine*, *4*(4), 199–204. https://doi.org/10.1007/BF02931258
38. Vezzulli, L., Pezzati, E., Brettar, I., Höfle, M., & Pruzzo, C. (2015). Effects of Global Warming on *Vibrio* Ecology. *Microbiology Spectrum*, *3*(3), 3.3.18. https://doi.org/10.1128/microbiolspec.VE-0004-2014
39. Yano, Y., Hamano, K., Satomi, M., Tsutsui, I., Ban, M., & Aue-umneoy, D. (2014). Prevalence and antimicrobial susceptibility of Vibrio species related to food safety isolated from shrimp cultured at inland ponds in Thailand. *Food Control*, *38*, 30–36. https://doi.org/10.1016/j.foodcont.2013.09.019
40. Yin, X., Zhuang, X., Liao, M., Huang, L., Cui, Q., Liu, C., Dong, W., Wang, F., Liu, Y., & Wang, W. (2022). Transcriptome analysis of Pacific white shrimp (Litopenaeus vannamei) hepatopancreas challenged by Vibrio alginolyticus reveals lipid metabolic disturbance. *Fish & Shellfish Immunology*, *123*, 238–247. https://doi.org/10.1016/j.fsi.2022.03.004

Disclaimer/Publisher's Note: The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of CMUJS and/or the editor(s). CMUJS and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.

CMU Journal of Science
The Official Scientific Journal of Central Mindanao University
ISSN Print: 0116-7847 js.cmu.edu.ph ISSN Online: 2704-3703

Research Article

Assessing Demand for a Graduate Nutrition and Dietetics Program in Northern Mindanao

Allene Mae N. Marapao1*, Marivic B. Lazar1, and Rachelle Gaye B. Caiña1.

1 Department of Nutrition and Dietetics, College of Human Ecology; Central Mindanao University, Musuan, Maramag, Bukidnon, Philippines, 8714

* Correspondence: Allene Mae N. Marapao: f.allenemae.marapao@cmu.edu.ph

A B S T R A C T.

The demand for Nutrition and Dietetics professionals in Mindanao Philippines is on the rise. Conducting this research work, the researchers determined the potential of the Master of Science in Nutrition and Dietetics (MSND) program, at Central Mindanao University (CMU). Market profile, demand situation, institution's readiness, faculty competency, location appropriateness and program viability were thoroughly examined. There were ninety-five (95) Bachelor of Science in Nutrition and Dietetics (BSND) students and alumni from Mindanao who participated in the survey. The findings revealed that majority of the respondents are willing to enroll to the MSND program due to growth, career advancement and is accessible in Mindanao. The respondents perceived that CMU can deliver the program well because of its professors, facilities and reputation. There is also a need for advanced nutrition professionals in both public and private sectors. The study found that the proposed MSND program is timely, relevant and meets the job needs of the region. The MSND program at CMU can help meet the growing need for nutrition and dietetics experts in Mindanao. Nutrition and dietetics practice can be improved with the program. The region's health and development efforts can benefit from the program.

Keywords: Nutrition and Dietetics, graduate education, program feasibility, higher education, Mindanao

Citation: Marapao, A. M., Lazar, M., & Caiña, R. G. (2026). Assessing Demand for a Graduate Nutrition and Dietetics Program in Northern Mindanao. CMU Journal of Science, 30(1), 117.

Academic Editor: Dr. Katherine Ann T. Castillo-Israel

Received: April 07, 2025
Revised: June 07, 2026
Accepted: June 24, 2026
Published: July 2, 2026

Copyright: © 2024 by the authors. Submitted for possible open access publication under the terms and conditions of the Creative Commons Attribution (CC BY) license (https://creativecommons.org/licenses/by/4.0/).

1. INTRODUCTION

Nutrition and dietetics are essential to addressing current public health concerns, such as malnutrition, food insecurity, obesity and diet-related non-communicable illnesses. The demand for highly skilled nutrition professionals is increasing worldwide and regionally as health care systems recognize the benefits of preventative and evidence-based nutrition interventions. The RNDs are required to have enhanced abilities in clinical nutrition, public health nutrition, food service management, research and policy development to be able to respond effectively to the increasing health challenges.

Higher education institutions are of great importance for developing specialized experts for the needs of society and the labor market. Recent studies have highlighted the importance of graduate education to professional competence, employability, innovation and regional growth. Graduate education in nutrition and dietetics develops research competence, evidence-based practice, leadership capabilities, and multidisciplinary collaboration of the professionals.

The Philippines' 2016 Nutrition and Dietetics Law (Republic Act No. 10862) acknowledge the significance of nutrition and dietetics professionals in developing and advancing the nation's health. However, even with the mandate, options for graduate study in Nutrition and Dietetics are still largely available in Luzon. At present there is just one graduate school in Nutrition and Dietetics (MSND) in Mindanao. Many professionals have to go out of the region for graduate studies. (Graduate School, University of Southern Mindanao. 2026. This geographical constraint creates financial, logistical and professional barriers that may dissuade RNDs and BSND graduates from pursuing additional studies. Nutrition and Dietetics Law of 2016, [n.d.]. Existing studies on the profitability of graduate programs and on the demand for higher education market but little study on the viability of launching an MSND program in Northern Mindanao. (Quinatac-an et al., 2025, pp. 3790–3809) There is a great deal of writing on the relevance of the undergraduate curriculum, employability or graduate education in various academic subjects. Further, little study has been conducted to explore the combined effect of institutional readiness, market demand, accessibility and industry needs on the feasibility of graduate nutrition programs in underserved areas. (Daud et al., 2025, pp. 1-10) (Khandelwal et al. 2014).

The study gap identified the absence of institutional capacity and market acceptance of CMU to provide MSND program to be assessed. CMU is well placed to address this gap in education. It is one of the best higher education institutions in Mindanao with extant undergraduate programs in nutrition and dietetics and great performance in licensure examinations. (CMU is the TOP PERFORMING SCHOOL November 2024 Nutritionist-Dietitians Licensure Examination, 2024).

Thus, this study was performed to assess the demand and feasibility of providing MSND program at CMU. The study also conducted an evaluation of the socio-demographic profile of prospective enrollees, managerial, market, operational, geographical and industrial feasibility of the proposed graduate program.

2. METHODOLOGY

2.1. Research Design

This study used a cross-sectional descriptive research approach to determine the feasibility of establishing a Master of Science in Nutrition and Dietetics (MSND) degree at Central Mindanao University (CMU). The study was designed to assess the market demand, management viability, operational readiness, site suitability and industry viability of the proposed graduate program.

2.2. Respondents and Sampling

The respondents were BSND students and graduates of colleges within Mindanao and its neighboring regions. Simple random sampling was used to achieve representation from a range of institutions offering nutrition and dietetics programs. Ninety-five respondents participated in the survey.

2.3. Research Instruments

Data were collected through a standardized online questionnaire based on past feasibility studies. Forlales & Lilang (2022); Roble & Tan (2021); Patalinghug & Patalinghug (2021). The instrument was somewhat modified to suit the objectives of the present study. In the pilot testing, Cronbach's alpha coefficient of 0.80 was obtained which indicated acceptable reliability and internal consistency.

2.4. Ethical Considerations

The study was approved by the institutional ethics review committee (IERC). Participation in this study was optional and all respondents provided informed consent prior to data collection. Respondents were promised of anonymity and confidentiality and of the ability to withdraw from the study at any stage.

2.5. Data Collection and Analysis

Data were collected using Google Forms and analyzed using descriptive statistical tools, such as frequency counts, percentages and weighted averages

3. RESULTS AND DISCUSSION

3.1. Profile of the Respondents

The respondents of this study is comprised of female and single (85.26%) and aged between 22 and 35 years. This matches trends in nutrition, where women mostly choose careers in dietetics and nutrition. Most respondents (96.84%) had a Bachelor of Science in Nutrition and Dietetics. This supports the idea that graduate programs work best when based on undergraduate training.

Table 1. Socio-demographic Profile of the Respondents

Variable	Category	Frequency (n)	Percentage (%)
Sex	Male	14	14.74
	Female	81	85.26
Civil Status	Single	81	85.26
	Married	14	14.74
Educational Attainment	BSND	92	96.84
	MS Degree holder	3	3.16
Employment	Government Agency	34	35.80
	Hospital/Clinical Setting	25	26.30
	Self-employed	22	23.30
	Others	14	14.60

A large number of respondents worked in government agencies (35.8%) hospitals (26.3%) or as self-employed nutrition professionals (23.3%). This variety shows that an MSND program needs to suit career paths like clinical, food service and community nutrition.

The findings also agree with studies of Thurech, Pelly, and Cooper (2020) and Zhou et al. (2024), that state that graduate programs should be in alignment with people's careers to increase job satisfaction and professional skills. These jobs show that people with a nutrition background want to advance their careers.

The study also found that the people with a degree in nutrition want to work in areas. The results agree with research that shows graduate programs are more effective with good undergraduate education. Most people who answered were women. Had a degree in nutrition, which is common in this field.

They were also mostly single and young which fits with trends. The jobs they had like working in hospitals or as self-employed nutritionists show they want to use their skills in ways. This supports the need, for a program that helps them advance their careers.

3.2. Management Viability

The management viability is the ability and efficiency of management in successfully managing and administering a new degree program (Wu and Cormican, 2021). It evaluates the management's present abilities, expertise, and strategic vision to see whether they can succeed in overcoming challenges, exploiting opportunities, and ensuring the long-term sustainability and expansion of the proposed new degree program (Abo-Khalil, 2024). Stakeholders

assessed the managerial viability of the MSND through a survey undertaken by the Department.

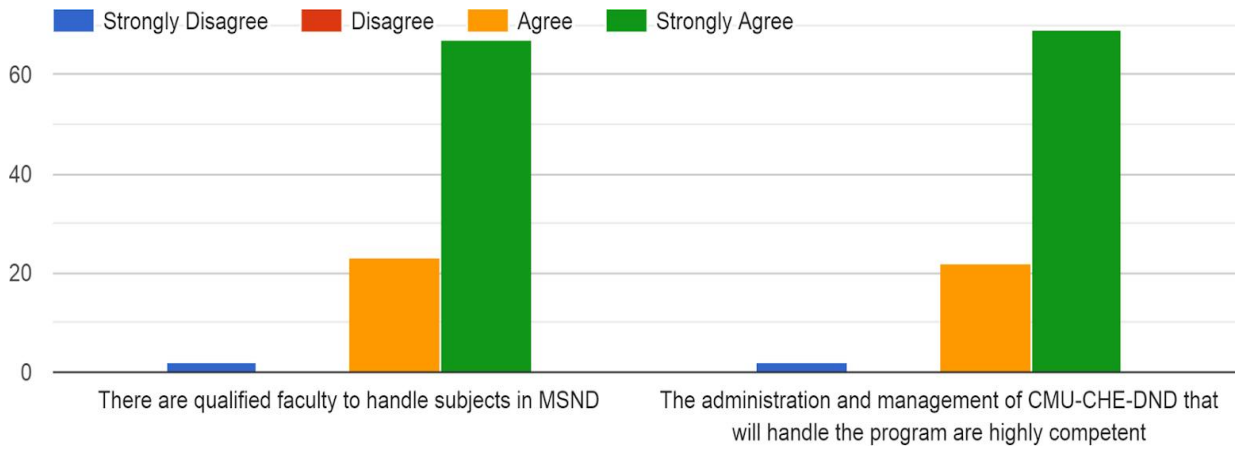


Figure 1. Management Viability of MSND

MSND program for career improvement and professional development. Result of this study simply presents how potential students perceive graduate study as a means to gain skills, increase professional opportunities, and develop expertise in the field of nutrition and dietetics.

Moreover, the strong interest in enrollment can be explained by human capital theory. Human capital theory states that the reason for taking higher education is to increase the productivity, employability and career prospects of the individual in the long run.

The results show that graduate education is a strategic investment in one's career development. This is in agreement with the findings of Patalinghug and Patalinghug (2021) , who highlight the importance of graduate education for career development. Moreover, Boak et al. (2025) discovered that students still prefer graduate programs in nutrition when they meet the needs of the market and professional development goals.

Also, the institutional image of Central Mindanao University may have added to the respondents' confidence in the proposed program. Previous research indicates that students' decision to pursue graduate study is significantly influenced by institutional legitimacy, teacher competency and program quality.

The analysis revealed a considerable market interest in the MSND program being offered. Most of the respondents said they would enroll if the program will be available in Mindanao. The main reasons that respondents gave were professional advancement, personal improvement and employability.

Figure 2 shows that there is a current educational gap in the area, with professionals wanting advanced nutrition education facing geographic and cost constraints due to restricted program choices. This would expand access to the MSND program, and reduce the burden for those who wish to pursue graduate courses outside Mindanao.

Other results indicate that the proposed program matches workforce demands in the healthcare, public health, community nutrition, and academic areas. The growing awareness of health problems related to nutrition shows the need for advanced nutrition specialists capable of conducting research, implementing interventions and contributing to evidence-based practice.

This approach strategically makes academic programs flexible to the changing needs of the labor market and employment trends, thus remaining relevant and attractive to prospective students (Abir et al., 2024). By proactively analyzing these factors, institutions can capitalize on emerging opportunities and enhance the effectiveness of the programs (Kalebar et al., 2024).

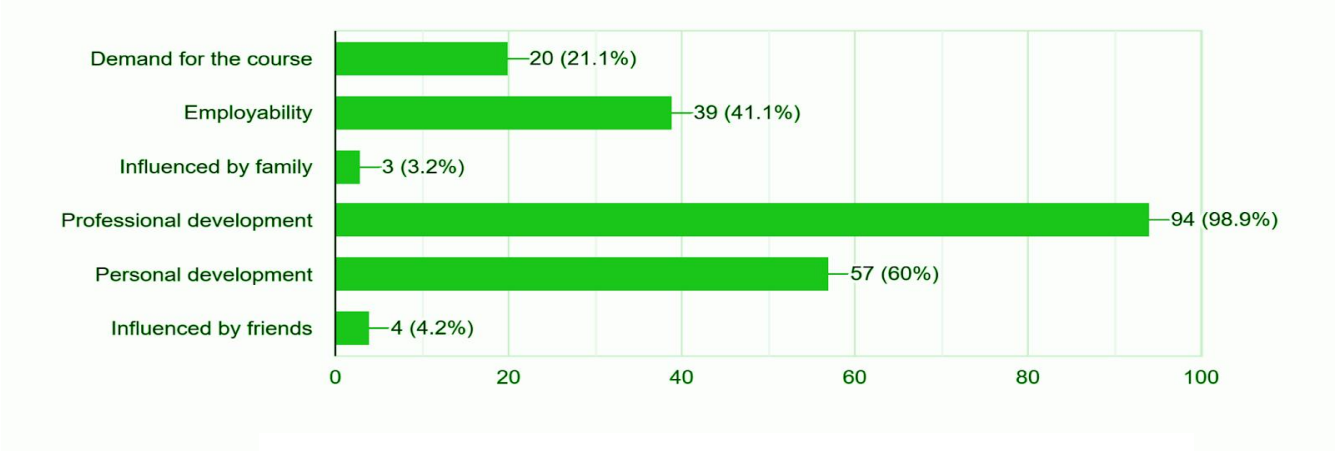


Figure 2. Respondents' Reasons for wanting to take MSND

Enrollment projections and market feasibility are valuable insight for academic institutions for program development and resource allocation (Parker, Walser, and Dighe, 2024). Learning of prospective student interest and market need for a specific program helps institutions to optimize resources, prepare for growth and improve student recruitment.

This strategic approach supports enrollment management strategies and ensures long-term profitability and sustainability of new degree programs. As seen in Figure 2, the respondents had high motivations in enrolling the Master of Science in Nutrition and Dietetics (MSND).

Respondents (98.9%) are motivated by professional development, 60% personal development and 41.1% employability. popularity in the nutrition and dietetics business (23.2%) and near the places where they are currently residing. Such foresight helps the institutions to decrease the risks, to make contingency plans and to optimize financial resources efficiently (Ušpurienė, Sakalauskas & Dumskis, 2017).

Financial planning and budgeting of colleges and universities can be improved through assessment of enrollment projections and market potential. Institutions can enhance their financial stability through revenue estimation, cost-effectiveness analysis, and data-driven decision-making. The respondents of the study are interested in the Master of Science in Nutrition and Dietetics (MSND) in Central Mindanao University (CMU) because of the good reputation (62.1%) as presented in Figure 3.

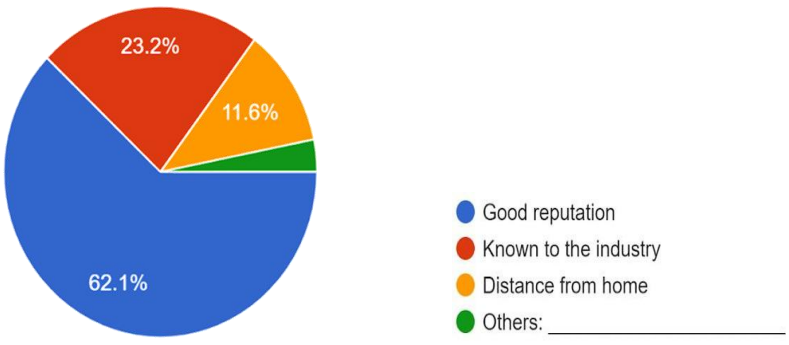


Figure 3. Respondents' Reasons for Wanting to Take MSND in CMU

3.4. Operational Viability

Introduction of a new degree program in an institution, it is necessary to determine the operational and financial feasibility that will ensure the success and sustainability of the program (Fernandez et al., 2025). Operational feasibility determines the ability of the higher education institution to implement the new program effectively including the availability of resources, facilities and expertise (Rodriguez-Zurita et al., 2025).

This evaluation identifies operational gaps or challenges that must be addressed before the program can commence to ensure smooth implementation and delivery.

Among people who took the survey, majority strongly agreed that Central Mindanao University (CMU) has what it needs to start the MSND graduate program (Figure 4). Respondents considered CMU to be equipped with the right facilities, adequately resourced for teaching, and staffed with qualified teachers. readiness of the school is actually a key thing for a program to flourish.

An unprepared university may negatively impact the teaching quality and student outcomes.

Based on the survey results, CMU can offer graduate education in nutrition. CMU has the existing nutrition programs, excellent teaching facilities and highly qualified teachers. These factors can contribute to the new program's success.

On top of that, being operationally ready means that the university can provide teaching assistance through research and extension activities, for graduate students. These are elements of preserving high academic standards and fulfilling what people expect from higher education. CMU has facilities and qualified faculty members to support graduate nutrition education. The readiness of the university is very important for the success of the program.

CMU has the ability to provide quality graduate level instruction with its current resources.

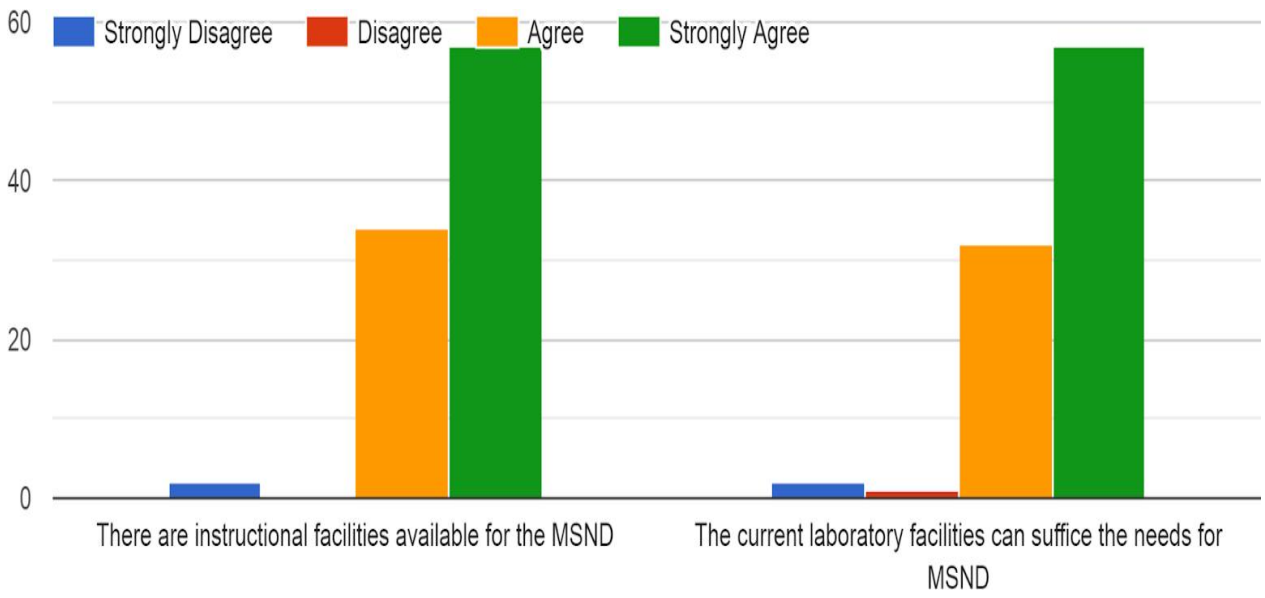


Figure 4. Operational Validity of MSND

3.5. Location and Industry Viability

The location of Central Mindanao University is a bonus for numerous people. Several participants revealed that they are ready to make the trip to CMU as it is conveniently accessible from different parts of Mindanao. For those in areas with no education options, being able to reach a school easily is a top priority.

One of the ways to find out if people really want to hire graduates from this program is by asking the extents of the demand through surveys or doing some research. The outcome is given in Figure 6.

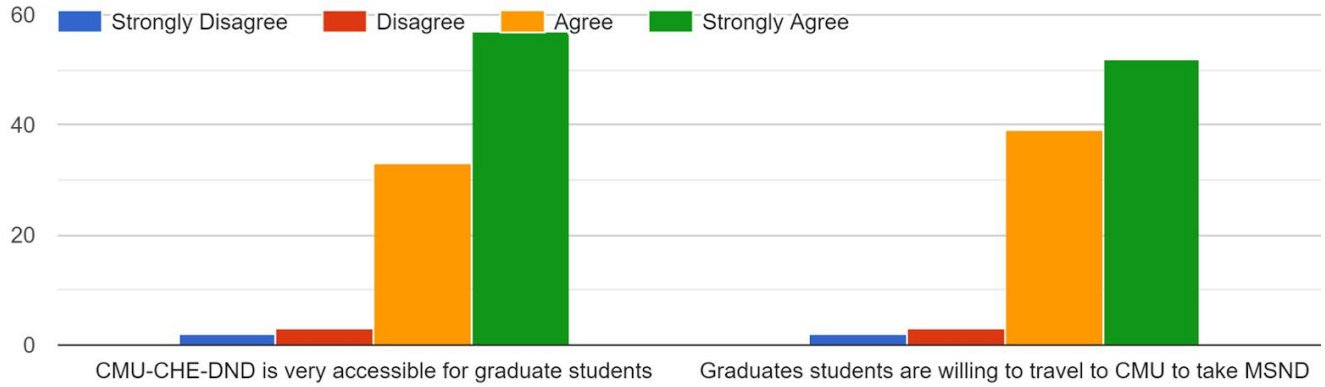


Figure 5. Location Viability of MSND

Most respondents in the survey find CMU very easy to reach and are willing to travel to attend the MSND program as seen in Figure 5. About location, CMU should also have the necessary infrastructure and qualified teachers to run the program. Having a pool of potential students locally is another essential aspect in ensuring the success of the program.

The population density in the surrounding areas and the availability of educational institutions mainly determine this. The industry appears to be looking for individuals knowledgeable in advanced nutrition and dietetics. This applies both to government as well as private sectors.

Presently, there is a lot of concern about food-related illnesses and unhealthy lifestyles. At the same time, there are efforts to achieve food security. Because of this, it is expected that the demand for nutrition professionals will continue for the next few years. This is the reason why the MSND program ranks high on the list of programs for the future. The MSND program has the capability to produce graduates with knowledge in nutrition, research, and leadership which is good for the overall development of the region.

Most respondents concurred that there is a demand for MSND graduates and that they can find jobs quite easily, in both private and public organizations. This shows the MSND program is something that the industry is really in need of.

The MSND program at Central Mindanao University can really help with development in the region and the whole country like the World Health Organization said would happen in 2018. Authors like Yang, Zhu and MacLeod (2018) and Basabe and Galigao think it is very important to have graduate programs that people in areas can get to (2024) so they can have a fair chance to get a good education and a good job.

Also, the market for this field is likely to keep growing. It is a good idea to have experts in this field. If the field is growing then more people will be needed to work in it which makes the MSND program a good idea.

It is great to see that the people who answered the questions think there will be a demand for the

MSND program in the next five years as shown in Figure 6.

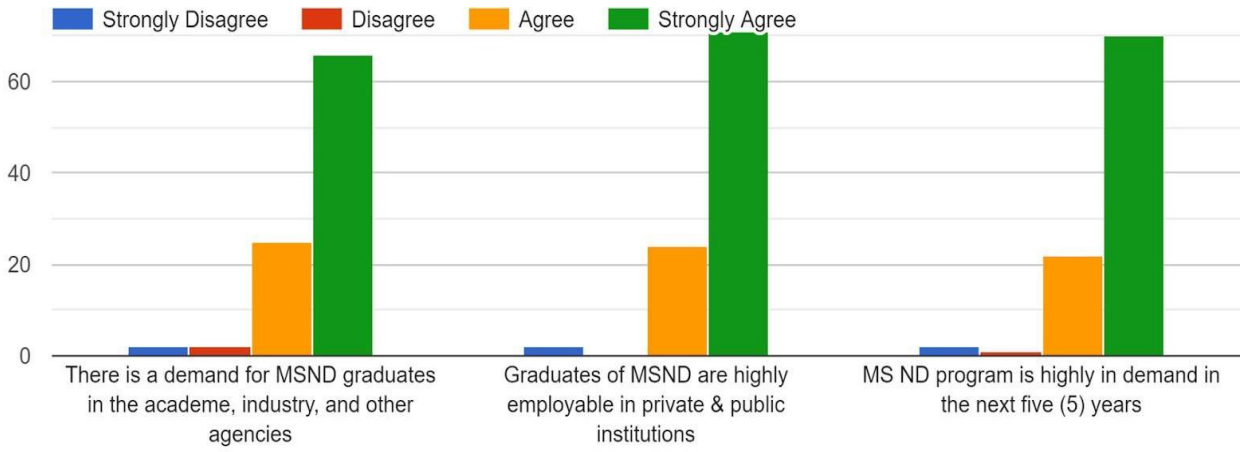


Figure 6. Industry Viability of MSND

When starting a new degree program, it is important to think about the location. If it is a good idea (Lou, Azadi, and Witlox, 2024; Vong et al., 2015; Zia, Tan, and Subramaniam, 2019). This is a move because it means the program will be relevant, sustainable and likely to succeed. It means the MSND program will meet the needs of the students the university and the community.

To gauge the perceived employability of MSND graduates, respondents were asked to assess the extent of industry demand for advanced nutrition and dietetics professionals. As shown in Figure 6, the majority of respondents agreed that there is a recognized demand for MSND graduates in both public and private sector organizations, and that graduates of such a program would have favorable employment prospects. These findings indicate that the proposed program is aligned with labor market needs and that prospective graduates are likely to secure relevant professional placements upon program completion.

4.CONCLUSION

The research revealed that the Master of Science in Nutrition and Dietetics (MSND) program of Central Mindanao University is suitable for the local setting. It may be instrumental in addressing the professional requirements of the residents here.

The figures indicated a lot of potential students, nutrition and dietetics young professionals inclined to pursue career advancement. They desire to specialize and climb the career ladder.

The capability of Central Mindanao University to offer the program is there. Besides that, they have faculty, good facilities, and a strong academic environment. And, the university is well accessible.

There is an increasing demand for competent nutrition professionals in the public and private sectors. So, the program should be relevant and sustainable for some time. Through the MSND program, nutritionist-dietitian professionals in Mindanao will have the advantage of continuing their studies at the graduate level in the field of nutrition and dietetics.

In conclusion, the proposed Master of Science in Nutrition and Dietetics program at Central Mindanao University holds considerable promise as a graduate program that addresses a documented gap in accessible advanced nutrition education in Mindanao. Subject to the completion of program development requirements, the MSND program is well-positioned to contribute meaningfully to professional capacity building, public health advancement, and regional development.

Author Contributions: AMM, MBL, and RGC: Conceptualization and design. Acquisition of data: AMM Data encoding, decoding and cleaning: AMM, MBL, and RGC. Manuscript writing: AMM. All authors

have read and agreed to the published version of the manuscript.

Funding: This study was the patriotic research (R2023-035) of the Department of Nutrition and Dietetics under the College of Human Ecology and still fully supported by the Research Office of Central Mindanao University (CMU).

Data Availability Statement: The authors confirm that the data supporting the findings of the study are available within the article. Raw data that support the findings of this study are available from the corresponding author upon reasonable request.

Acknowledgments: The authors would like to express their sincere gratitude to all respondents for their cooperation and participation in this study.

Conflicts of Interest: The authors declare no potential conflicts of interest with respect to research, authorship, and/or publication of this study.

5. REFERENCES

1. (2026). Graduate School – University of Southern Mindanao. University of Southern Mindanao. https://www.usm.edu.ph/academics/graduate-school/
2. (December 15, 2024). Central Mindanao University is the TOP PERFORMING SCHOOL in the November 2024 Nutritionist-Dietitians Licensure Examination. Central Mindanao University. https://www.cmu.edu.ph/central-mindanao-university-is-the-top-performing-school-in-the-november-2024-nutritionist-dietitians-licensure-examination/
3. (n.d.). Nutrition and Dietetics Law of 2016. https://www.digest.ph/laws/nutrition-and-dietetics-law-of-2016
4. Abo-Khalil, A. G. (2024). Integrating sustainability into higher education challenges and opportunities for universities worldwide. Heliyon, 10(15), e35464. https://doi.org/10.1016/j.heliyon.2024.e35464
5. Academy of Nutrition and Dietetics. (2017). Nutrition care process and model. Journal of the Academy of Nutrition and Dietetics, 117(5), 741-753. https://doi.org/10.1016/j.jand.2017.10.002
6. Basabe, G. B., & Galigao, R. P. (2024). Enhancing career opportunities through equal access to quality education. Journal of Education and Practice, 15(4), 1-10.
7. Boak, R., Palermo, C., Beck, E. J., Pelly, F., Wall, C., & Gallegos, D. (2025). Five actions to strengthen the nutrition and dietetics profession into the future: Perspectives from Australia and New Zealand. Journal of Human Nutrition and Dietetics, 38(3), e70064. https://doi.org/10.1111/jhn.70064
8. Daud, N. M., Guimba, W. D. & Naga, M. M. (2025). Employability Characteristics of Teacher Education Graduates in Mindanao State University. International Journal of Research in Social Science and Humanities 6(4), pp. 1-10. https://doi.org/10.47505/IJRSS.2025.6.4
9. Fernandez, F., Provin, A., Birch, R. S., Aguiar Dutra, A. R., & Andrade Guerra, J. B. S. O. D. (2025). Integrating social impact: A model for assessing Brazilian graduate programs aligned with sustainable development goals. International Journal of Sustainability in Higher Education, 26(9), 174-194. https://doi.org/10.1108/IJSHE-03-2024-0132
10. Forlales, E. L., & Lilang, R. P. (2022). Stakeholders' assessment on offering Master of Engineering programs in Romblon State University: Feasibility study. Journal of Positive School Psychology, 6(8), 10535-10546.
11. Kalebar, R. U., Mahadev, A. V. R., Naveen, C. L., & Das, D. K. (2024). Strategic management in higher education: Navigating challenges and opportunities. Journal of Informatics Education and Research, 4(1), 97-104.
12. Khandelwal, S., Paul, T., Haddad, L., Bhalla, S., Gillespie, S. & Laxminarayan, R. (2014). Postgraduate education in nutrition in south Asia: a huge mismatch between investments and needs. BMC Medical Education 14. https://doi.org/10.1186/1472-6920-14-3
13. Lou, Y., Azadi, H., & Witlox, F. (2024). Factors influencing site selection for higher education institutes: A meta-analysis. Land, 13(12), 2123. https://doi.org/10.3390/land13122123
14. Parker, M. A., Walser, T. M., & Dighe, S. (2024). Academic program development: A collaborative and context-sensitive approach. Discover Education, 3(1), 272. https://doi.org/10.1007/s44217-024-00377-3
15. Patahlinghug, M. E., & Patahlinghug, H. F. (2021). Market needs assessment for Bachelor of Science in Industrial Security Management in a state-funded college. Jurnal Pendidikan Progresif, 11(3), 602-609. https://doi.org/10.23960/jpp.v11.i3.202117

16. Quinatac-an, Y. B., Quinatac-an, F. J. & Castino, J. M. (2025). Feasibility Study on the Conversion of the Existing Special Science Curriculum to Science, Technology, and Engineering (STE) Program at Silway-8 National High School. Journal of Educational and Social Research 9(3), pp. 3790-3809. https://doi.org/10.36941/jesr-2025-0130
17. Roble, D. B., & Tan, R. G. (2021). A feasibility study on the University of Science and Technology of the Southern Philippines offering a Bachelor of Elementary Education major in science, technology, engineering, and mathematics (STEM). Asia Pacific Journal of Educational Perspectives, 8(1), 38-43.
18. Rodríguez-Zurita, D., Jaya-Montalvo, M., Moreira-Arboleda, J., Raya-Diez, E., & Carrión-Mero, P. (2025). Sustainable development through service learning and community engagement in higher education: A systematic literature review. International Journal of Sustainability in Higher Education, 26(1), 158-201. https://doi.org/10.1108/IJSHE-03-2024-0106
19. Thurecht, R. L., Pelly, F. E., & Cooper, S. L. (2020). The influence of current food and nutrition trends on dietitians' perceptions of the healthiness of packaged food. Public Health Nutrition, 23(12), 2124-2131. https://doi.org/10.1017/S1368980019005029
20. Ušpurienė, A., Sakalauskas, L., & Dumskis, V. (2017). Financial resource allocation in higher education. Informatics in Education, 16(2), 289-300. https://doi.org/10.15388/infedu.2017.14
21. Vong, J., & Song, I. (2015). Important factors in choosing tertiary education institutes. In Emerging technologies for emerging markets (pp. 155-170). Springer. https://doi.org/10.1007/978-981-287-347-7_11
22. World Health Organization. (2018). Global nutrition policy review: What does it take to scale up nutrition action? World Health Organization. https://www.who.int/publications/i/item/9789241501194
23. Wu, Q., & Cormican, K. (2021). Shared leadership and team effectiveness: An investigation of whether and when in engineering design teams. Frontiers in Psychology, 11, 569198. https://doi.org/10.3389/fpsyg.2020.569198
24. Yang, H. H., Zhu, S., & MacLeod, J. (2018). Promoting education equity in rural and underdeveloped areas: Cases on computer-supported collaborative teaching in China. Eurasia Journal of Mathematics, Science and Technology Education, 14(6), 2393-2405. https://doi.org/10.29333/ejmste/89841
25. Zhou, Y., Liu, Y., Xue, W., Li, X., Yang, Z., & Xu, Z. (2024). Factors that influence the intent to pursue a master's degree: Evidence from Shandong Province, China. Frontiers in Psychology, 15, 1284277. https://doi.org/10.3389/fpsyg.2024.1284277
26. Zia, A., Tan, P. L., & Subramaniam, G. (2019). Criteria and priorities of secondary school students in choosing their educational pathway: A selection process by analytic hierarchy process. Malaysian Journal of Consumer and Family Economics, 22(2), 233-247.

Disclaimer/Publisher's Note: The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of CMUJS and/or the editor(s). CMUJS and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.

Journal of Science

CENTRAL MINDANAO UNIVERSITY

Call for Papers
Volume 31
2027 ISSUE

Check out our guidelines and send your manuscript(s)



journalofscience@cmu.edu.ph



js.cmu.edu.ph



CMU JournalofScience