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ASSESSMENT OF FACULTY PERFORMANCE AND STUDENT OUTCOMES DURING THE PANDEMIC: BASIS FOR ACADEMIC PROGRAM ENHANCEMENT

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ABSTRACT

The COVID-19 pandemic has significantly impacted higher education, necessitating a reexamination of factors influencing student academic outcomes. This study investigates the relationship between faculty performance and students' academic achievements during the pandemic across four programs offered by the College of Computer Studies (CCS). Using a quantitative approach, the research analyzes faculty evaluations and student academic records from four semesters amid the pandemic, aiming to uncover correlations between faculty performance and student success. The findings reveal that while CCS students generally exhibited satisfactory academic performance, retention rates were above average, and faculty performance ratings were also above average, the analysis indicates no significant correlation between faculty performance and students' academic achievements. Based on these insights, a set of recommendations is proposed to enhance faculty teaching strategies and student engagement. Further research is recommended to build on these findings and explore additional factors that may influence student success in the BSIT, BSCS, BSIS, and BLIS programs.

Keywords: academic performance, faculty performance, retention rate, correlation, coefficient of variation, COVID-19 pandemic

INTRODUCTION

Pursuing quality education is a global priority, with Sustainable Development Goal 4 (SDG 4) emphasizing the need for inclusive and equitable quality education (UNICEF, 2022). In recent years, many countries have adopted innovative approaches to improve education quality, particularly through the integration of technology and data-driven decision-making. The Philippines is also actively working to enhance the quality of education by aligning with global standards through national initiatives. The Philippine Development Plan (PDP) 2023-2028 outlines a comprehensive strategy for improving the quality of education across all levels. One of the plan's key components is the strengthening of the higher education sector by increasing access to quality education and promoting innovative practices, including the use of data analytics to support evidence-based policymaking and program improvements (NEDA, 2023). This aligns with the objectives of this study, which utilizes data analytics to examine the performance of both faculty and students, providing actionable insights that can inform improvements in teaching and learning processes in the College of Computing Studies (CCS).

The Commission on Higher Education (CHED) has been also instrumental in promoting quality assurance in higher education through accreditation processes, flexible learning programs, and support for innovative research. Further, in the Philippines, Higher Educational Institutions (HEIs) are continually striving to ensure that students receive the best possible education (Ian Benablo et al., 2018). This includes regular evaluations of two key stakeholders—faculty and students—to assess and enhance the effectiveness of educational delivery. The performance of these stakeholders serves as a crucial indicator for measuring institutional success in delivering quality education. In fact, analysis of academic performance is a vital input to the HEIs in devising interventions to ensure that quality education is achieved.

Aside from that, analysis of students' academic performance is also a criterion in program accreditation and evaluation. For State Universities and Colleges (SUCs), the Accrediting Agency of Chartered Colleges and Universities in the Philippines (AACCUP), Inc. mandates the periodic analysis of faculty and student performance as part of program evaluation and accreditation processes (Glenda De Lara, n.d.).

Traditionally, the academic performance of students in HEIs is assessed through metrics such as final grades and retention rates, while faculty performance is measured using instruments like the Qualitative Contribution Evaluation (QCE) (Philippines. Department of Budget and Management, 1998). However, the shift to distance or flexible learning during the COVID-19 pandemic introduced new challenges, as many students lacked access to the necessary resources due to economic disparities (Mahdy, 2020). During the surge of the Covid-19 pandemic, all levels of the education system in the Philippines were mandated to shift from face-to-face learning to distance or flexible learning. This method of learning offers an alternative way to reduce contact between students or between students and teachers. However, in the Philippines, many students do not have access to online education due to a lack of resources as a result of the economic and digital divide (Mahdy, 2020). Several studies show that this new education set-up impacts and brings challenges both to the educators and students in several ways like mentally and emotionally (Pragholapati, 2020)(Mahdy, 2020)(Sahagun & Tuazon, 2020). Computing Students (students enrolled in Information Technology Education programs) are among those greatly affected by this transition in the mode of learning. These transitions could affect also their academic performance since the ITE programs are originally designed for face-to-face learning since this includes hands-on activities where most cannot be delivered virtually especially if the students don't have the necessary resources and equipment (Joyce Ann L. Rocamora, n.d.).

Despite the wealth of research on the academic performance of engineering and medical students (Mahdy, 2020; Palmer, 2013) there is limited analysis of the performance of computing students, especially when comparing pre-pandemic and pandemic data. . Also, analysis and comparison of the academic performance of the computing students before and amidst the pandemic to determine the pandemic impact on the academic performance of the computing students were not covered. Most of the analyses were conducted for different purposes such as to determine the relationship between computing students' initial and final academic performance; prediction for future work performance and future career success, and predicting the impact of social media usage on academic performance (Amazona & Hernandez, 2019; Ian Benablo et al., 2018; Palmer, 2013; Samson Balogun et al., 2019). Further, several studies have already been conducted on the analysis of the faculty performance (Bhatnagar Associate Professor & Sahai Saxena Director, n.d.; K, 2019; Nowell, 2010; Singh & Gopal, 2010) however correlating the faculty performance and the academic performance of the students amidst the pandemic is not yet covered.

Data analytics provides a powerful tool for processing large datasets and generating actionable insights (Ruta & Cen, 2015). By applying this technology to faculty evaluation results and student grades, this study seeks to identify patterns and correlations that can inform actionable recommendations for improving performance. The findings of this study will serve as the basis for a plan of action aimed at enhancing both student and faculty performance in the College of Computing Studies (CCS). The action plan is expected to outline specific actions that will be taken by concerned individuals or entities based on the issues identified through data analytics. Action taken will all focus on how the issues will be resolved with a goal of enhancing or improving the performance of both faculty and students of CCS. These action plan may have a tangible impact by promoting more effective teaching practices, increasing student engagement, and enhancing overall academic performance in the College of Computing Studies (CCS).

It was in light of the above-mentioned context that this study was conducted. This study was initiated to effectively use data analytics to present and visualize the meaningful insights extracted from faculty performance evaluation results and students' final grades amidst the pandemic. Furthermore, the study attempted to correlate faculty performance with the academic performance of computing students. The meaningful insights gained as a result of data analytics served as input for recommendations to the school administration for a plan of action or interventions that could be implemented in the teaching-learning process. Finally, as computing educators, the researchers earnestly desired to contribute to achieving the goal of the Information Technology Education system as a whole.

OBJECTIVES OF THE STUDY

Overall, this study tries to extract meaningful insights from the academic performance of the students from the College of Computer Studies (CCS) and faculty performance evaluation results of the CCS faculty members of the Camarines Sur Polytechnic Colleges (CSPC) amidst the pandemic. Further, this study attempts to discover the possible relationship between faculty performance with the student's academic performance.

Specifically, this study seeks to achieve the following:

1. Describe the students' academic performance in terms of:
   a. Overall Performance in all the enrolled courses;
   b. Retention Rate;
2. Describe the overall performance of the CCS faculty members based on student-faculty evaluation rating;
3. Determine if there is a significant relationship between the faculty performance and the student's academic performance.
4. Propose a plan of action based on the insights gained from the analysis to further improve the teaching-learning process.

METHODOLOGY

Anchored to the objectives of this study, the researcher adopts the quantitative method approach where quantitative data, final grades of CCS students, and faculty performance evaluation results were collected and analyzed.

For data analytics, the procedure was guided by the Data Analytics Process (What Is Data Analytics and Its Future Scope in 2021, n.d.) as shown in Figure 1.

Figure 1. Data Analytics Process

As shown in Figure 1, the data analytic process will be guided by these steps:

Understand the Problem: In this step, the researcher defines the problem, frames objectives, crafts a preliminary hypothesis to be tested, and assesses the availability of the data sources (Long, 2018). Further, the hypotheses to be tested were defined as follows:

Ha: There is a significant relationship between the faculty performance and the student's academic performance;

Ho: There is no significant relationship between the faculty's performance and the student's academic performance.

Data Collection: This is the step where the collection of data commences. Class records, student-faculty evaluations, class observation results, and IPCR ratings were retrieved from the dean's office with the due approval of the dean. The coverage of the collected dataset is from the first semester of AY 2020-2021 to the second semester of AY 2021-2022.

Data Cleaning: In this step, data were preprocessed and conditioned in preparation analysis (Long, 2018). The datasets were structured in such a way it will be easy to load on the data analytic tool to be

used. The datasets were double-checked also for missing or null values. Data from the data set which will have no purpose for analysis were removed also.

Data Exploration and Analysis: This is the step where the actual data analysis commences. Data visualization and statistical technique tools, specifically MS Excel, were used. The datasets were analyzed using both descriptive and inferential statistics. Descriptive statistics was used to describe and visualize the collated dataset. In particular, for the first and second objectives of this study, the mean (average) was utilized to calculate the overall performance and retention rate of students as well as the overall performance of faculty in terms of student-faculty evaluation, class observation, and IPCR rating. Moreover, the Coefficient of Variation (CV) was a supporting statistical analysis tool to examine the overall performance of the CCS faculty within the covered period in terms of consistency. Lastly, inferential statistics was conducted to determine the relationship between faculty performance and students' academic performance. This was done using Spearman's Correlation, which is appropriate for assessing the strength and direction of an association between two ranked variables. It is a useful method of analysis in cases where the data does not necessarily have a normal distribution; hence, it applies to ordinal data or even non-parametric data.

Interpret the Results: This step involves interpreting the analysis results to determine whether the outcomes align with the expectations and if the hypothesis is supported or rejected. The insights gained from this analysis directly inform the recommendation for a plan of action. These evidence-based recommendations are designed to address the areas of concern uncovered during the analysis and to improve the teaching and learning process within the College of Computer Studies. The result summarized the strong and weak points and these were the focus of every recommended interventions.

FINDINGS

A.1 Academic Performance of CCS Students

To evaluate the impact of the pandemic on student learning outcomes, the academic performance of CCS students across four programs—BSIT, BSCS, BSIS, and BLIS—was analyzed over four consecutive semesters from SY 2020-2021 to SY 2021-2022. This analysis provides valuable insights into how each program adapted to the challenges of flexible learning modalities and highlights areas for potential enhancement to ensure sustained academic success.

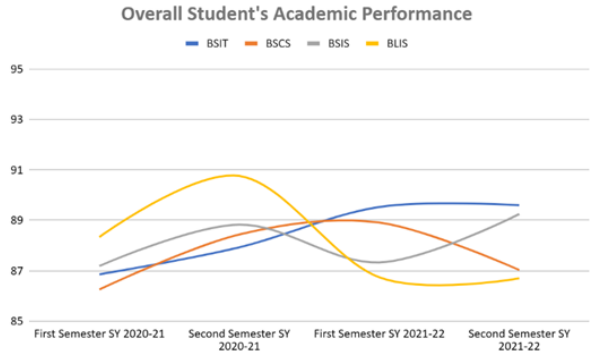

Figure 2. Overall Student's Academic Performance

As shown in Figure 2, the BSIT program demonstrated consistent improvement, starting at 86.86 in the first semester of SY 2020-2021 and steadily rising to 89.6 by the second semester of SY 2021-2022, consistently within the Satisfactory range. Similarly, BSCS showed an upward trend, peaking at 88.44 before slightly declining to 87.03 in the final semester, remaining in the Satisfactory category. BSIS maintained stable performance, increasing gradually to 89.25 in the final semester, also within the Satisfactory classification. In contrast, BLIS students began with a Very Satisfactory score of 90.76 but declined to 86.7 by the last semester, shifting back to the Satisfactory range.

The consistent improvement in BSIT and the stability of BSIS highlight the programs' ability to adapt to the challenges posed by the pandemic. The slight fluctuation in BSCS performance suggests room for further enhancement but demonstrates overall resilience. The decline in BLIS performance, from Very Satisfactory to Satisfactory, could indicate program-specific challenges such as increased workload demands, shifts in student engagement, or difficulties in transitioning to flexible learning modalities. These variations reflect each program's distinct response to the pandemic's disruptions and underscore the importance of tailored academic and support strategies.

These findings align with the broader literature on academic performance during the pandemic, which emphasizes that consistent support and adaptability are critical for maintaining student achievement. Spitzer and Musslick (2021)found that low-achieving students often benefited from structured online learning platforms, suggesting that well-organized academic delivery can enhance performance. Similarly, Iglesias-Pradas et al.(2020) noted that effective organizational strategies during emergency remote teaching improved academic outcomes across programs. The variability observed in BLIS performance may reflect findings by Panagouli et al. (2021), who identified challenges for students in specialized or resource-intensive programs during the pandemic, emphasizing the need for targeted interventions to mitigate learning disruptions.

This analysis is limited to quantitative data on academic performance and does not incorporate qualitative insights into students' experiences, challenges, or specific program-level factors that may have influenced the results. Additionally, external factors such as socioeconomic conditions, access to technology, and individual student circumstances were not examined, which could have significantly affected performance outcomes. Future research should include surveys or focus groups to provide a more comprehensive understanding of the underlying factors contributing to these trends.

In summary, the academic performance of CCS students amidst the pandemic demonstrates resilience, with BSIT and BSIS showing consistent or stable results, while BSCS displayed slight fluctuations. The notable decline in BLIS performance highlights the need for tailored interventions to address program-specific challenges. These findings emphasize the importance of ongoing monitoring, targeted support strategies, and adaptive academic practices to ensure sustained academic success, particularly during periods of disruption.

A.2 Retention Rate of CCS Students

This analysis highlights trends in student persistence during a period marked by significant shifts in educational delivery, offering insights into program resilience and areas for potential support enhancement.

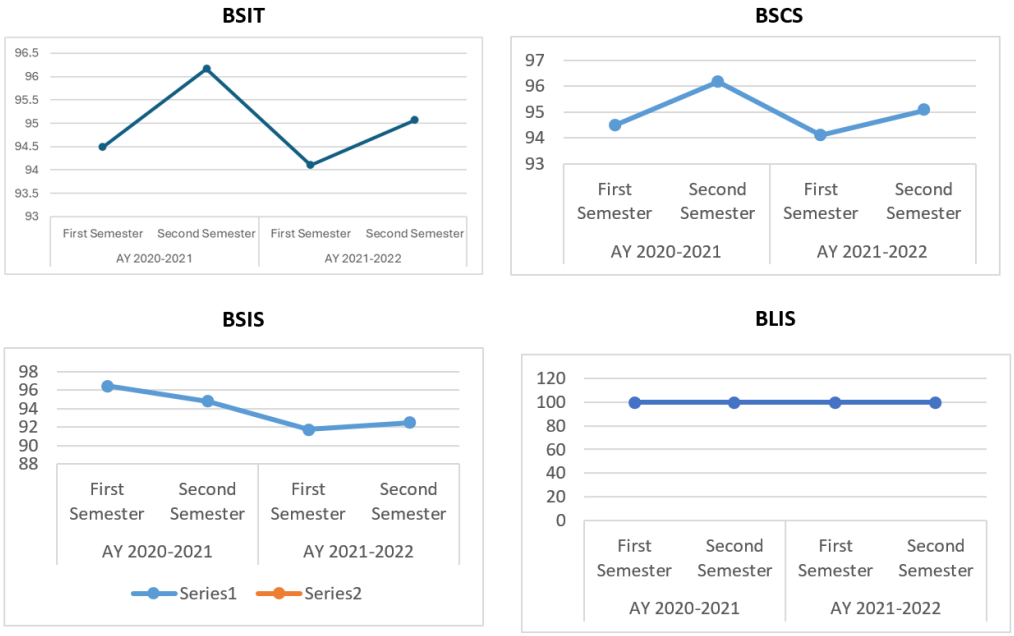

Figure 3. Overall Retention Rate

The retention rates across the four programs—BSIS, BSIT, BSCS, and BLIS—display a generally positive trend over the two academic years affected by the COVID-19 pandemic. The BSIT and BSCS programs maintained consistently high retention rates, peaking in the second semester of the 2021-2022 academic year with retention rates of 96.17% and 98.91%, respectively. The BSIS program, although experiencing some decline, maintained retention rates above average, indicating students' engagement despite challenging conditions. Notably, the BLIS program reported a perfect 100% retention rate across all semesters, indicating complete student retention throughout the period.

The high retention rates in BSIT, BSCS, and BLIS suggest that students in these programs remained committed to their studies despite the transition to remote learning, perhaps due to the support structures provided by their institutions during the pandemic. The slightly lower but still strong retention in BSIS may reflect some unique challenges encountered by students in this program, though the retention levels still demonstrate significant engagement. BLIS's perfect retention could indicate particularly robust program-specific support or curriculum design that fostered high levels of student persistence.

These findings align with existing literature indicating that institutional support and a positive learning environment are key to retaining students during crises. According to Tinto (2017), students' perceptions of support, engagement, and resource accessibility significantly influence their retention decisions, especially in online or remote contexts. Similarly, Stone and Springer (2019)found that institutions that quickly adapted their learning environments to maintain continuity and engagement during disruptions achieved higher retention and satisfaction levels among students. This aligns with the present findings, suggesting that the programs with strong support and adaptable structures, such as BLIS, saw consistently high retention rates. Moreover, Martin and Bolliger (2018) emphasize that high-quality instruction, interactive learning, and accessible resources are essential for fostering engagement in online environments, which further supports the importance of responsive institutional strategies in sustaining student persistence.

This analysis is limited by the contextual factors specific to the COVID-19 pandemic, which may not apply in other scenarios. Additionally, while retention rates provide a valuable indicator of student engagement and program success, they do not capture other factors influencing retention, such as students' academic challenges, economic issues, or personal circumstances. This analysis also does not include qualitative feedback from students, which could provide deeper insights into their experiences and the support structures that were most effective.

B. Performance of CCS Faculty Members

The subsequent figures provide a visualization of the performance rating of CCS faculty members for AY 2020-2021 to AY 2021-2022.

OVERALL RATING	BSIT	BSCS	BSIS	BLIS
Student-Faculty Evaluation	4.34	4.45	4.37	4.59
Class Observation	3.82	3.86	3.81	3.96
IPCR	4.40	4.41	4.20	4.47
AVERAGE	**4.19**	**4.24**	**4.12**	**4.34**

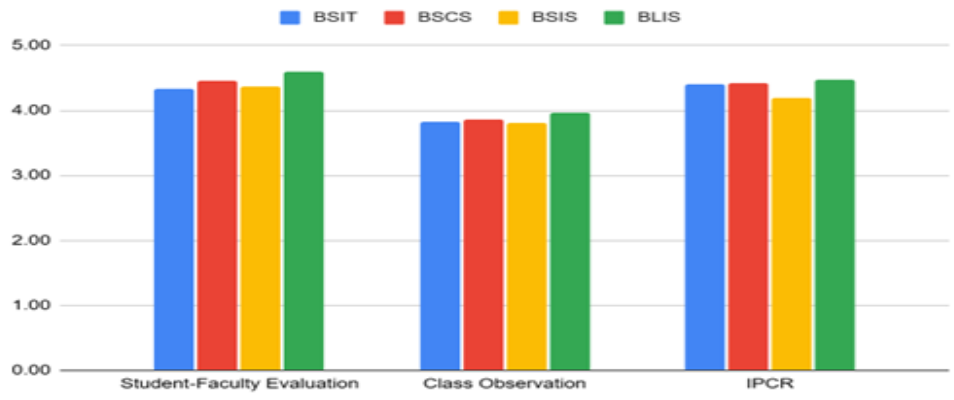

Figure 7. Overall Rating

The faculty performance of CCS faculty members across the BSIT, BSCS, BSIS, and BLIS programs during the four semesters of the pandemic (SY 2020-2021 to SY 2021-2022) was consistently strong, as evaluated through Student-Faculty Evaluations, Individual Performance Commitment Ratings (IPCR), and Class Observation. Student-Faculty Evaluations showed high satisfaction, with BLIS faculty consistently rated the highest (peaking at 4.00 in SY 2021–2022) and BSIT showing recovery after an initial dip. Similarly, IPCR scores reflected steady and exceptional performance, with all programs peaking above 4.40 in the final semester. Class Observation ratings demonstrated upward trends across most programs, with BSCS and BLIS achieving their highest scores of 4.64 and 4.70, respectively. The overall ratings suggest strong faculty commitment, with the BLIS program standing out as the highest-performing.

These results indicate that faculty in all programs maintained high performance standards despite the challenges posed by the pandemic, reflecting their adaptability and dedication. The consistently high ratings in IPCR evaluations, particularly for BSCS and BLIS, point to faculty members' ability to meet and exceed performance goals during a period of significant disruption. While the initial dip in BSIT's Student-Faculty Evaluations suggests early challenges in adjusting to new teaching modalities, the program's subsequent recovery demonstrates resilience and effective adaptation. BLIS's consistent high scores across all metrics reflect a robust alignment between faculty efforts and student satisfaction.

The observed performance trends align with research highlighting the importance of faculty adaptability, resourcefulness, and engagement during crises. According to Martin and Bolliger (2018), student satisfaction and effective faculty performance in online or hybrid learning environments are strongly influenced by the perceived quality of teaching and the faculty's ability to create a supportive learning atmosphere. Similarly, Stone and Springer (2019) emphasize the role of interactive and adaptive teaching strategies in maintaining high levels of satisfaction and performance during disruptions. The BLIS program's outstanding ratings may reflect these factors, suggesting that faculty in this program employed particularly effective strategies to support student learning and engagement. Conversely, the initial fluctuations in BSIT ratings align with findings by Iglesias-Pradas et al. (2020)which noted that transitions to remote teaching can initially challenge faculty performance, requiring time and institutional support to stabilize outcomes.

This analysis relies on quantitative performance data, which may not fully capture the nuanced challenges and efforts of faculty members during the pandemic. Factors such as variations in course content, student demographics, and faculty workload were not explored and may have influenced the results. Additionally, the evaluations reflect a snapshot of performance and do not account for long-term trends or qualitative feedback from students and faculty. Future studies could include qualitative data to provide deeper insights into faculty performance and its drivers.

In summary the faculty performance across the CCS programs during the pandemic was commendable, with BLIS emerging as the highest-performing program, followed closely by BSCS. The consistently high ratings in IPCR, Student-Faculty Evaluations, and Class Observation demonstrate the faculty's resilience, adaptability, and commitment to maintaining instructional quality. While the findings highlight areas of strength, particularly in the BLIS and BSCS programs, they also point to opportunities for targeted support in programs like BSIT and BSIS to ensure sustained excellence in faculty performance across all metrics. These results reaffirm the value of proactive faculty development and continuous evaluation as key strategies for navigating educational challenges.

C. Relationship Between Faculty Performance and Students' Academic Performance

Table 3 corresponds to the summarized correlation test result across all courses and the average faculty performance ratings of the respective course instructors per program.

Table 3. Correlation Test Result Between Faculty Performance and Students' Academic Performance

Program (Faculty Performance vs Students' Academic Performance	Correlation Coefficient (ρ)	p-value	Decision
BSIT	-0.183	0.361	Accept Ho
BSCS	-0.334f	0.111	Accept Ho
BSIS	-0.187	0.605	Accept Ho
BLIS	0.345	0.126	Accept Ho

The correlation analysis reveals distinct patterns across the programs studied, though none of these relationships were statistically significant at the α=0.05 level.

For the BSIT, BSCS, and BSIS programs, the correlation coefficients of -0.183, -0.334, and -0.187, respectively, suggest weak negative relationships between faculty performance and student academic performance. A negative correlation indicates an inverse relationship, implying that as faculty performance ratings increase, student academic performance tends to decrease slightly. However, these weak correlations do not imply causation. Factors such as course difficulty, student effort, and individual learning styles may mediate this relationship. Additionally, highly-rated faculty may teach more challenging courses or adopt rigorous grading standards, which could affect student grades despite high teaching quality.

For the BLIS program, the correlation coefficient of 0.345 indicates a weak positive relationship, suggesting a slight tendency for student academic performance to improve as faculty ratings increase. Nevertheless, this correlation is also weak and does not indicate a strong or substantial relationship.

Importantly, the p-values for all programs (=0.361 for BSIT, p=0.111 for BSCS, p=0.605 for BSIS, and p=0.126 for BLIS) exceed the significance threshold (α=0.05). This means that we fail to reject the null hypothesis, indicating no statistically significant relationship between faculty performance and student academic performance in any of the programs.

Figure 5 further visualizes the correlation test result through a scatter plot. As can be gleaned, points are scattered randomly, indicating no apparent relationship between the variables (faculty performance and the student's academic performance).

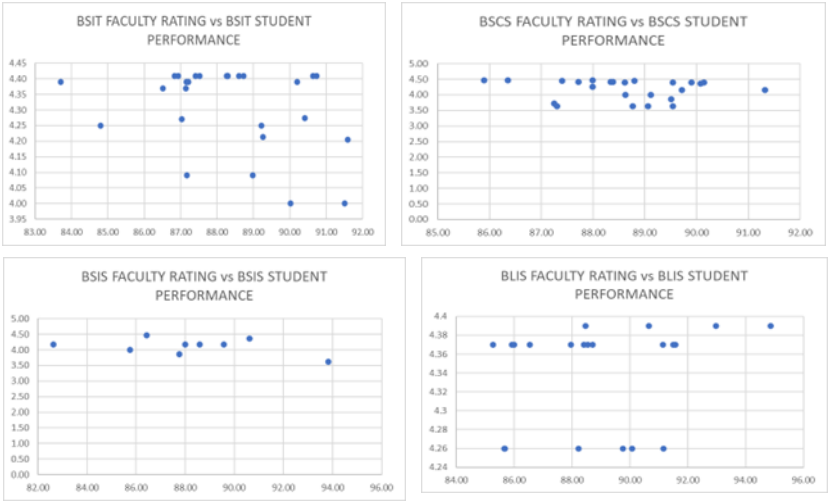

Figure 5. Correlation Visualization for BSIT, BSCS, BSIS and BLIS

The negative correlations observed in BSIT, BSCS, and BSIS suggest an inverse relationship, where higher faculty ratings are associated with lower student grades. This could be attributed to various factors, such as faculty with high ratings potentially teaching more challenging or rigorous courses, which might naturally result in lower student grades. Additionally, stringent grading practices by highly-rated faculty could contribute to this trend. On the other hand, the weak positive correlation observed in BLIS suggests that faculty performance might play a minor role in enhancing student outcomes. Despite this, the strength of these correlations—whether negative or positive—is weak to moderate at best, indicating that faculty performance alone is not a definitive predictor of student academic success.

These findings align with literature that emphasizes the multifaceted nature of student academic performance. For instance, Darkwa et al. (2021) and Farooq et al. (2011)highlight that academic outcomes are influenced by a broad array of factors, including socioeconomic status, student effort, learning environments, and external stressors. Similarly, Martin and Bolliger (2018)argue that while faculty performance is critical, it is not the sole determinant of academic success, as other elements such as course design, assessment methods, and student engagement play significant roles.

The lack of statistically significant correlations underscores the need for a holistic approach to improving student outcomes. While maintaining high teaching standards is crucial, institutions should address other critical factors, such as curriculum design, student support services, and equitable access to resources. These findings also suggest that faculty evaluation metrics should not be used in isolation to gauge teaching effectiveness or predict student success. Instead, institutions should adopt comprehensive evaluation frameworks that consider qualitative and quantitative factors, including student engagement and satisfaction, classroom dynamics, and broader institutional support.

This analysis is limited by its reliance on quantitative correlation measures, which do not capture the complexity of the factors influencing both faculty performance and student academic outcomes. Variables such as student motivation, classroom environment, and external stressors were not included in the study, which may have contributed to the weak correlations. Additionally, faculty ratings might not fully reflect teaching quality, as they can be influenced by subjective student perceptions, course difficulty, or grading leniency. Future research should explore these factors through qualitative methods, such as interviews or focus groups, to provide a more comprehensive understanding of the dynamics at play.

D. Plan of Action to Further Improve the Teaching and Learning Process

Based on the revealed insights, the following plan of actions are proposed for the improvement of the BSIT, BSCS, BSIS, and BLIS programs in terms of teaching and learning processes.

Faculty Development Programs. Faculty development initiatives that align with the expertise of BSIS faculty members will focus not only on technical knowledge but also on pedagogical methods to effectively transfer knowledge to students. By enhancing teaching strategies, faculty can foster a more engaging and supportive learning environment, improving student performance (Hammond et al., 2017). Workshops on active learning and student engagement can help create dynamic classrooms that cater to diverse learning styles, thus improving overall student success.

Continuous Review of Syllabus Content. Regular updates to the syllabus ensure that the course content is aligned with current industry trends and the intended learning outcomes. By keeping the syllabus relevant and flexible, students will engage with the most up-to-date material, helping them develop the skills needed in the ever-evolving fields of business and computing (Gibbs, 2018).

Mentoring and Peer Tutoring. Interventions such as peer tutoring programs can provide personalized academic support to students who may be struggling, particularly in challenging courses like programming. Peer mentoring fosters a sense of community and allows students to learn from each other, which has been shown to improve academic outcomes and retention (Boud et al., 2013).

Consultation Hours. Reinforcing the importance of consultation hours ensures that students receive individualized support, enhancing their understanding of the material. Faculty-student interactions during these hours help address academic challenges, provide clarity on course content, and foster positive student-faculty relationships, which can lead to improved student engagement and performance (Bryson & Hand, 2007).

Monitoring and Observations. Regular monitoring of classroom activities by Program Chairs and Deans, through observations and honest feedback, ensures that teaching standards are maintained. This practice allows for early identification of teaching challenges, which can be addressed to improve the quality of instruction and, consequently, student learning outcomes (Shernoff et al., 2003).

Data Analytics. Utilizing data analytics to track student performance and retention rates allows faculty and administration to identify patterns and intervene early when students are struggling. By using insights from student performance data, the teaching and learning process can be continuously improved through targeted interventions (Siemens, 2013).

CONCLUSION

Based on the results and interpretations presented, the researchers came up with the following conclusions:

1. Despite the fact that CCS students attained satisfactory to very satisfactory academic performance in the majority of the courses amidst the pandemic, still, analytics revealed that there are courses in which students tend to have difficulty, therefore, a prompt intervention to improve the academic performance of students in these courses is necessary.

2. Above-average retention ratings in most courses amidst the pandemic is commendable however there are still courses with low retention rates, and therefore these must be given attention.

3. The performance of CCS faculty members amidst the pandemic is above average despite of challenges however, the variability of performances over the different rating periods needs more attention especially those faculty with declining performance ratings.

4. Faculty performance is not a determinant of student's academic success in their respective courses. The negative correlation between faculty ratings and student academic performance prompts further investigation. While it's important to value student feedback on faculty, it's equally crucial to consider other variables that might influence student performance beyond just faculty performance.

RECOMMENDATION

The researchers came up with the following recommendations for future improvement of this study:

1. The College of Computer Studies may implement targeted academic support programs, such as peer tutoring, remedial class, or faculty-led review sessions, for courses where students experienced difficulty.

2. The College of Computer Studies may develop and institutionalize retention strategies, such as enhanced academic advising, and at-risk student identification program, to identify at-risk students early and provide early intervention strategies.

3. A structured faculty development and mentoring program should be reinforced to provide continuous training, peer coaching, and performance monitoring, ensuring that faculty members receive the necessary support to enhance their teaching effectiveness overtime.

4. Further research should be conducted to explore other possible determinants of student academic success which are less explored such as socio-emotional factors, institutional policies and practices, and the students' health or well-being.

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OPTIMIZING RESOURCE UTILIZATION TO ENHANCE MILITARY TRAINING OUTCOMES

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ABSTRACT

This study investigates the impact of resource management on the quality of military training at the School for Candidate Soldier, Training Command, Philippine Army, aligning with SDG 4 (Quality Education). Focusing on the resource component of the military training triad, it examines the utilization of facilities, equipment, and financial resources. Descriptive research employing quantitative method was used to gather data from primary sources. Key findings include best practices such as proactive facility maintenance, designated equipment caretakers, and proactive funding initiatives. However, challenges identified include time-consuming facility construction, equipment damage due to improper handling, and potential fund diversion. These findings highlight the need for improved resource management strategies to enhance training quality. The study recommends implementing a unit directive or policy to enforce best practices and address identified weaknesses.

Keywords: Resource Management, Military training, Best Practices, Policy directive, Challenges in managing resources

INTRODUCTION

The military training triad, encompassing faculty, training design/program, and resources is paramount across all training domains. The interconnected framework significantly influences the success or failure of any training endeavor. Mirroring the Commission on Higher Education (CHED's) pursuit of educational excellence, the Armed Forces of the Philippines Education and Training Evaluation System (AFPETES) Manual (2018) guides all training evaluations, prioritizing quality outcomes. This aligns with Sustainable Development Goal 4, which emphasizes inclusive opportunities for all, as defined by the United Nations.

These three important factors (faculty, training design/program, and resources) in education should be emphasized to achieve this goal. In competency-based education, faculty development is a potent instrument that enhances instruction and learning and can foster creativity and organizational transformation (Atkinson, et al (2024). Faculty development programs are planned to enhance faculty members' research, teaching, and counseling skills. These programs are essential for addressing gaps in instruction quality and adapting to evolving academic standards.

Further, employee training programs represent a strategic investment by organizations, spearheaded by Civilian Human Resource and Talent Development offices and departments. These initiatives are integral to the employee experience, providing a critical platform for upskilling and reskilling the workforce. Equipping employees with new competencies or refining existing skills, training programs empower individuals to enhance their productivity, elevate their performance, and potentially transition seamlessly into new roles within the organization.

The relevance of effective training programs for military organizations extends beyond individual soldier development. Prioritizing and investing in comprehensive training initiatives, the military not only enhances individual soldier proficiency but also strengthens the overall operational effectiveness of the force. Improved training programs directly contribute to increased mission readiness, enhanced combat effectiveness, and reduced casualties. Furthermore, well-structured training fosters a cohesive and resilient unit culture, strengthening camaraderie and enhancing unit cohesion.

Moreover, within the military context, effective training programs must address the unique needs and challenges faced by service members. These include, but are not limited to, physical and mental resilience training, combat skills development, cultural awareness training, and leadership development programs. Moreover, as emphasized by Flores (2024), training programs must incorporate a strong emphasis on ethical conduct, legal compliance, and the provision of reasonable accommodations for service members. This focus on inclusivity fosters a more equitable and supportive environment for all service members, ensuring that every individual has the opportunity to thrive and contribute to the mission.

While faculty expertise and well-designed training programs are undeniably crucial, the availability and effective utilization of resources significantly influence the attainment of quality education. As articulated by Resource Dependency Theory, organizations, including educational institutions, are inherently dependent on external resources to function effectively. The ability to secure and control essential resources, such as financial support, technological infrastructure, and human capital, is paramount for organizational success (Hillman, A.J. et al., 2009). This emphasis on the critical role of resources aligns with Resource-Based Theory, which posits that organizations with access to and control over valuable, rare, and inimitable resources possess a significant competitive advantage (University of Minnesota Library Publishing Edition, 2015), alongside faculty expertise and the availability of resources.

While acknowledging the equal importance of all key components, this study focuses on a strategic approach to resource management with the specific aim of optimizing the utilization of facilities, equipment, and financial resources to achieve superior military training results.

Military institutions rely heavily on a robust foundation of resources, primarily categorized as Facilities, Materials, and Equipment (FME). These resources are essential for efficient and effective operational capabilities. This aligns with broader definitions of resources as valuable assets, encompassing materials, capabilities, and entities that enable the fulfillment of needs, the achievement of goals, and the advancement of societies, organizations, and individuals (Kumar et al., 2023).

The significance of effective resource management is underscored by quantitative management theory, which provides a framework for optimizing resource utilization (Wamalwa, 2023). This is crucial, as understanding the contribution of resources – including financial, physical, (facilities, equipment), and human – is paramount for the success of any training program. Furthermore, resources exhibit diverse forms, ranging from tangible assets to intangible elements such as human skills and knowledge (David, 2000). This multifaceted nature necessitates a comprehensive approach to resource management.

Moreover, the efficient management of resources is crucial to ensure their optimal utilization and sustainable availability. This involves resource planning, which assesses needs, sets priorities, and strategically allocates resources effectively. Resource allocation considers factors such as demand, urgency, cost-effectiveness, and potential benefits to optimize resource utilization (Daniels, et al., 2016). This aims to maximize the value and efficiency of resource usage by minimizing waste, reducing inefficiencies, and continuously improving resource management processes. Similarly, resources such as facilities, equipment, and finance are fundamental to the success of any training program. Thus, efficient resource management is crucial (Pukahuta et al., 2022)

Training facilities, encompassing buildings and fixtures, are indispensable for effective knowledge transfer to students/trainees. Their sustained functionality is paramount for institutions like the School for Candidate Soldier (SCS) to maintain uninterrupted training programs. As emphasized by Mormah (2023) citing Abraham (2003), facility maintenance focuses on preserving the original condition of completeness and efficiency of grounds, buildings, and equipment. Neglect can significantly diminish the functionality, aesthetic appeal, and value of educational facilities, hindering the teaching-learning process. Proactive maintenance, adhering to the principle of "a stitch in time saves nine", is crucial for extending the lifespan, enhancing the aesthetic appeal, and ensuring optimal operational use of school facilities. Furthermore, building upon the principles of facilities management theory, the Asset Lifestyle Management (ALM) framework advocates for a holistic approach to facility management. This comprehensive framework encompasses the entire lifecycle of facilities, from initial design and construction to decommissioning, ensuring their optimal utilization and long-term sustainability.

While, Military training, like any educational endeavor, relies heavily on the effective use of equipment. This encompasses both teaching aids utilized by instructors during classroom instruction and those essential for the overall operation of the institution. According to Sayan (2020), equipment plays a crucial role in supporting and enriching the learning-learning process within the military context. It is not merely a standalone element but rather an integral component that facilitates and enhances learning ef-

fectiveness. Recognizing the diverse nature of nature and learning situations, it's important to note that no single piece of equipment can be universally effective. The suitability of equipment often varies depending on the specific subject matter being taught.

Several key benefits of utilizing equipment in military training have been identified by researchers (Yalin, 2003; Demirel et al., 2022 as cited by Sayan, 2020). First, equipment can effectively transform abstract concepts into tangible, concrete experiences, making them easier for trainees to grasp. Second, it significantly enhances learner interest, motivation, and attention creating a more engaging learning environment. Third, the use of equipment can streamline the teaching-learning process, leading to significant time savings. Fourth, it ensures consistency in content delivery across different training periods. Fifth, equipment can be effectively tailored to address the individual learning needs and styles of different trainees. Sixth, it offers the advantage of reusability, maximizing its cost-effectiveness. Seventh, equipment can simplify complex concepts, making them more accessible and easier to understand. Finally, the use of equipment has been shown to significantly improve long-term retention and memory recall. The effective integration of equipment is paramount to the success of military training programs. Carefully selecting and utilizing appropriate equipment, instructors can create more engaging, effective, and efficient learning experiences for trainees. This not only enhances the overall quality of training but also contributes to the development of highly skilled and competent military personnel. Further, military activities and training are entirely dependent on adequate financial resources. These encompass monetary assets, capital, and funds utilized by organizations and individuals to support economic activities, including savings, investments, loans, grants, and revenue generated from operations. As outlines by King Rice et al. (2020), the financial aspect of any organization is multifaceted, encompassing three critical functions: revenue generation, resource allocation, and resource utilization. These functions collectively contribute to the provision of training opportunities and the achievement of desired military outcomes.

Financial resources are indispensable for the success of any organization, as aptly stated by Yizengaw ang Agegnehu (2020). No organization, irrespective of its nature, can thrive without a secure financial foundation. Consequently, institutions, firms, and organizations must prioritize sound financial management practices to enhance their performance and mitigate exposure to financial risks (Munge, Kimani & Ngugi, Citation 2016).

Echoing this sentiment, Ogbonnaya (2020) as cited by Yizengaw and Agegnehu emphasizes that the primary objective of financial management is to ensure the most efficient and effective utilization of available funds. Given the inherent scarcity of resources, educational administrators bear the responsibility of optimally and prudently allocating available funds to achieve institutional objectives. Poor financial management can have detrimental consequences, including embezzlement, the diversion of funds from critical projects, and misappropriation of resources.

Hence, we can say that effective resource management is paramount for the success of any organization, including military institutions. While best practices like prioritizing procurement and meticulous planning are crucial for efficient resource utilization, challenges such as limited budgets, infrastructure constraints, and increasing demand can significantly hinder operational effectiveness (Reeder, 2023).

In the context of military training, these challenges manifest in various ways, such as delays in infrastructure development due to funding shortages and personnel limitations can impede training progress. Furthermore, the growing number of trainees necessitates the expansion of facilities, including classrooms, libraries, and recreational areas. However, the availability of resources for facility procurement may not always keep pace with the growing demand.

Addressing these challenges requires a multifaceted approach. This necessitates not only securing adequate financial resources, as highlighted by Aung et al. (2029), but also implementing strategies to enhance the efficiency and sustainability of existing resources. This may involve fostering a culture of maintenance, exploring innovative resource utilization strategies, and leveraging technology to optimize training delivery.

Recognizing the critical importance of effective resource management, the School for Candidate Soldier (SCS) within the Training Command proactively strives to innovate and optimize its resource allocation. This includes enhancing existing facilities, procuring additional educational and training equipment, and implementing robust financial management practices.

However, despite these efforts, a significant gap exists in the documentation and dissemination of the SCS's experiences in resource management. The lack of published scholarly articles on the practices,

challenges, and outcomes of resource utilization within the SCS creates a knowledge gap hindering the understanding and replication of successful strategies.

To address this gap, this study aims to develop a comprehensive unit policy that will serve as a guiding framework for effective resource management within the SCS. This policy will provide a clear set of principles and procedures for all members of the institution to adhere to, ensuring optimal resource utilization.

STATEMENT OF THE PROBLEM

This study aims to determine the factors that optimize resource utilization. Understanding these factors, the study will propose policy/directive recommendations to enhance resource management practices and ensure they are responsive to the evolving training needs of the military. Specifically, the study answered the following questions:

1. What is the demographic profile of the respondents in terms of:
   1.1 Age
   1.2 Sex
   1.3 Civil status
   1.4 Highest Educ attainment
   1.5 Current designation?
2. What are the best practices observed in the management of resources in terms of:
   2.1 Facilities
   2.2 Equipment
   2.3 Financial?
3. What are the common problems encountered in the management of resources in terms of:
   3.1. Facilities
   3.2 Equipment
   3.3 Financial?
4. What are the Strengths, Weaknesses, Opportunities, and Threats associated with resource management practices, considering both best practices and common problems encountered in this area?
5. What are the recommendations to further enhance the management of resources to be more responsive to the training needs?

METHODOLOGY

Research Design

The study utilized the descriptive research design using a quantitative method. This method aimed to comprehensively investigate resource management practices, identify associated challenges, and formulate recommendations for improvement. Descriptive research, as defined by Mahajan (2020), seeks to understand the current phenomenon. The primary goal of using the quantitative method is that it deals with numeric data that can be analyzed statistically (Hera, et al (2024).

Research Locale

The study was conducted at the School for Candidate Soldier, Training Command, Philippine Army, located at Camp O'Donnell in Santa Lucia, Capas, Tarlac. This institution was selected as the research site due to its pivotal role as the Philippine Army's primary pre-entry training school for newly enlisted soldiers. The setting provides the researcher with direct access to valuable insights and expertise from seasoned military training professionals, thereby enhancing the study's credibility and relevance.

Research Participants

The respondents who completed the survey instruments were the training staff, training NCOs, and Pekiti-Tersia Kali instructors. Total enumeration was used to determine the number of respondents, resulting in a total of twenty-eight respondents composed of 5 training staff, 21 training NCOs, and 2 PTK instructors with 100% turn-in.

Research Instrument

Data for this study was collected using a researcher-made survey questionnaire, incorporating both open-ended questions which were validated by three military training experts with extensive evaluation experience. This mixed methods approach aimed to capture both the respondents' specific views (through closed-ended questions on a 5-point Likert scale) and their detailed perspectives and suggestions (via open-ended questions).

The questionnaire was divided into three sections: 1) Respondent demographics; 2) Resource Utilization Best Practices, and 3) Challenges encountered. This approach was supported by Awson (2002) who argued that a combination of question types enhances respondent engagement and allows for the exploration of new issues, proving effective in gathering comprehensive data.

Data Gathering Procedure

Data collection commenced with a brief orientation session at the school's gazebo. During this session, the research objectives and survey procedures were explained to the participants. Subsequently, survey questionnaires were distributed to each respondent. Completed questionnaires were collected two weeks later.

Data Analysis

The results of the questionnaires were analyzed and interpreted. Parts 1 to 3 of the questionnaire which are the demographic profile, practices and challenges, frequency counts, percentages, and average weighted mean were used. Frequency counts and percentages were used to describe the respondent's answers to the survey, while the average weighted mean was used to describe which of the items per indicator garnered the most number of responses from the respondents.

Ethical Considerations

The researchers secured permission from the Commandant of the School for Candidate Soldier to survey the personnel of the school. Respondent participation was voluntary, and informed consent was obtained from all participants. To ensure confidentiality, respondent identities and responses were kept strictly private.

FINDINGS

The demographic profile revealed that most of the respondents are young, predominantly male, and within their prime productive years, which are highly beneficial for the organization. This aligns with the findings from the studies of Durdyev and Mbachu (2018) and Sigdel and Subedi (2024), which emphasize the significance of employee employability and the impact of relevant skills training on individual productivity and organizational competitiveness. Considerable effort has been invested in developing training programs that equip trainees with the skills and knowledge necessary to excel in their military careers.

Table 1. Practices Observed in the Management of Resources

Indicators	Weighted Mean	Description
Facilities		
1. Conduct repair and maintenance of the training facility before, during, and after the training.	4.32	Highly Practiced
2. Determine the equipment needed for the training for planning and fund allocation.	3.49	Moderately Practiced
3. Conduct weekly updates on the status of facilities.	3.40	Moderately Practiced
4. Prioritize the repair and maintenance of the facilities in allocating funds.	4.18	Highly Practiced
5. Engage other government agencies and NGOs in constructing additional training facilities through joint projects.	4.18	Highly Practiced
Average Weighted Mean	**3.91**	**Highly Practiced**
Equipment		
1. Continuously procuring additional equipment for PTK training.	3.43	Moderately Practiced
2. Conduct repair and maintenance of equipment before, during, and after the training.	3.30	Moderately Practiced
3. Conducts inventory of equipment such as knives, pistols, sticks, and rifles.	4.11	Highly Practiced

4. Provide training equipment to the Candidate Soldiers and let the students do the responsibility of maintaining the equipment.	4.21	Highly Practiced
5. Designate personnel who are knowledgeable of storing, repairing, and maintaining the PTK equipment.	4.25	Highly Practiced
Average Weighted Mean	**3.86**	**Highly Practiced**
Financial		
1. Conducts budget deliberation	3.43	Moderately Practiced
2. Provide enough fund support for the training.	3.45	Moderately Practiced
3. Send a request to higher headquarters for additional fund support for PTK training.	4.21	Highly Practiced
4. Conducts weekly updates on the financial status of the unit	4.14	Highly Practiced
5. Ensures that the fund support is distributed according to the budget allocation of the activities.	4.11	Highly Practiced
Average Weighted Mean	**3.87**	**Highly Practiced**

On SOP 2, Key results indicate that facilities management demonstrated the highest perceived effectiveness among the assessed resource management practices, achieving an average weighted mean (AWM) of 3.9, while equipment management exhibited the lowest perceived effectiveness with an AWM of 3.86. The highest best practice in facilities management, with an average weighted mean (AWM) of 4.32, was the regular maintenance of training facilities before, during, and after training sessions. This finding underscores the school's strong emphasis on ensuring the serviceability of all training facilities. As highlighted by Yazdi (2024), the longevity and efficiency of machinery, equipment, and systems are paramount in military and educational training environments. Adhering to sound maintenance procedures and strategies, training institutions can optimize asset performance and extend their lifespan.

Moreso, proactively prioritizing the repair and maintenance of facilities through budgetary allocations and strategic partnerships with government agencies (such as DND-DPWH "TIKAS Program") and NGOs is crucial for the long-term sustainability of training infrastructure. While weekly conferences are currently utilized for communicating facility status updates, exploring the use of digital platforms for more frequent and timely updates could further enhance communication and facilitate proactive maintenance efforts.

Regarding equipment management, respondents highly valued the school's practice of assigning knowledgeable personnel to oversee equipment storage, repair, and maintenance (AWM 4.25), a practice that aligns with the Army's principle of "the right man for the right job". Furthermore, the school effectively empowered students by incorporating instruction on basic equipment maintenance procedures and providing them with the responsibility of safely storing equipment (4.21 AWM). These practices resonate with the findings of Riyawadi et al. (2024), which emphasize the critical role of ongoing training, knowledge sharing, effective hiring and retention strategies, improved communication channels, and enhanced teamwork in maximizing field service operations, elevating service standards, and increasing customer satisfaction within organizations.

While, in terms of financial management, the study revealed that frequent requests for additional funding support from higher headquarters for PTK training were a common practice (4.21WM). While weekly updates on the unit's financial status were consistently provided (4.14 WM), a significant challenge identified was insufficient budgetary allocation to fully support all training needs (3.45 WM). Furthermore, the study highlighted a lack of formal budget deliberation processes (3.43 WM) within the unit.

Table 2. Challenges/Problems Encountered

	WM	DER
Facilities		
1. The training area/venue is not adequate for a large number of trainees/students.	3.93	Often
2. Classrooms are not spacious enough for classroom instructions.	3.89	Often
3. Billeting facilities are not enough to cater to a large number of students.	3.75	Often
4. It takes time to construct additional training facilities.	4.55	Always
5. Comfort rooms are also limited and some need immediate repair.	4.51	Always
Average Weighted Mean	**4.12**	**Always**
Equipment		
1. There is a shortage of training paraphernalia (sticks, knives, pistols, rifles, etc.)	3.71	Often
2. Training sticks (arnis sticks) are not sturdy.	4.50	Always
3. Lack of training knives and bolos.	3.68	Often

4. Lost equipment due to improper recording.	3.71	Often
5. Some equipment was damaged due to improper usage and storage.	4.52	Always
Average Weighted Mean	**4.02**	**Always**
Financial		
1. Fund support is not enough to cater to the training needs.	3.75	Often
2. Funds are sometimes diverted to other projects or programs.	3.79	Often
3. The current per capita covers the conduct of Basic Military Training of Candidate soldiers and not of the Pekiti-Tersia Kali training. Thus, not enough fund was allocated for the PTK training.	3.75	Often
4. Sometimes the training schedule was not followed due to the delay in the release of fund support.	3.71	Often
5. The delay in the release of fund support intended for the training resulted in the juggling of funds.	3.82	Often
Average Weighted Mean	**3.71**	**Often**

In terms of Challenges encountered, it was revealed that facilities management presented the highest frequency of encountered problems (AWM 4.12), while financial management exhibited the lowest frequency (AWM 3.71). Analysis of facilities challenges revealed significant limitations, with respondents expressing strong concerns regarding the school's ability to construct additional facilities (WM 4.55) and the urgent need for repairs to existing comfort rooms (WM 4.51). These findings underscore the inadequacy of current facilities to accommodate the growing number of trainees.

This inadequacy inevitably impacts training schedules and overall implementation timelines and can also adversely affect the quality of training. As highlighted by Julistia et al. (2025) citing Talitha et al. (2020), adequate investment in quality training facilities plays a crucial role in improving access to quality military services.

Furthermore, increased investment in training can significantly enhance its quality by enabling the provision of skilled trainers, appropriate educational equipment, and modern technologies. A well-educated military workforce is essential for driving economic growth and improving the overall well-being of society. The quality of training facilities directly correlates with the school's productivity and the economic well-being of its members, as it equips individuals with the necessary skills and knowledge to meet the demands of contemporary military service.

On equipment management, the identified challenge was the damaged equipment due to improper usage and storage (AWM not specified). This resulted in a shortage of essential training equipment, particularly training knives and bolos. As emphasized by Cuong Phu et al. (2020), effective equipment management is critical for project success and yields economic benefits for the institution. Consequently, equipment damage and shortages can lead to inefficiencies in training delivery.

A significant challenge identified in financial management was the impact of financial constraints and delays in the release of training funds (WM 3.83). these delays frequently necessitated the reallocation of existing budgets (WM 3.79), often disrupting planned training schedules. As emphasized by the Department of Budget and Management (DBM, 2016), public funds must be utilized effectively and efficiently to maximize their impact on the public good. Delays in formulating and disseminating detailed and clear guidelines to implementing agencies, as observed in this study, can significantly hinder the timely utilization of funds and potentially delay future disbursements (Archarya, 2020). These delays not only disrupt training programs but also undermine the efficient and effective use of public resources.

SWOT Analysis

The study revealed that the School for Candidate Soldier (SCS) excels in resource utilization, demonstrating several key strengths. Notably, the school prioritizes the upkeep of its training facilities through consistent repair and maintenance before, during, and after training programs. This proactive approach, coupled with prudent fund allocation, ensures optimal training environments. Furthermore, the SCS boasts adequate billeting and spacious training venues, readily accommodating large cohorts of trainees. The school also emphasizes human capital by assigning knowledgeable personnel to manage equipment storage, repair, and maintenance. Regular equipment inventories, including knives, pistols, sticks, and rifles, are conducted, and Candidate soldiers are actively trained on equipment maintenance procedures and entrusted with safe storage responsibilities. Finally, the availability of sufficient training paraphernalia and the meticulous record-keeping of all equipment, combined with weekly updates and fair distribution of funds according to the allocated budget, further solidify the school's strengths in resource management.

Despite the commendable strengths in resource management demonstrated by the School for Candidate Soldier, still some areas need improvement. The construction of crucial additional training facilities

has been significantly delayed due to prolonged delays in the release of earmarked funds. This has not only hindered the expansion of training capabilities but also impacted on the overall training environment. Furthermore, the study revealed a need for immediate repairs for certain training facilities, particularly comfort rooms. Additionally, some training equipment exhibited signs of wear and tear, likely attributed to improper usage and inadequate storage practices. This not only compromises the safety and effectiveness of training but also necessitates increased maintenance costs. Finally, the observation that training sticks used in arnis training lack sufficient sturdiness highlights a potential under allocation of funds specially for Pekiti-Tersia Kali (PTK) training. This inadequate funding directly impacts the quality of training materials and may hinder the effective delivery of essential PTK instruction.

The study also revealed the presence of external factors that significantly influence the operations of the SCS. Notably, positive external factors include collaborative partnerships with other government agencies and NGOs. These collaborations have facilitated the construction of additional training facilities through joint project initiatives. Furthermore, support from Higher Headquarters, particularly through the provision of additional funds upon request, has provided SCS with valuable resources. These external factors present valuable opportunities for the SCS to leverage these resources to further enhance its strengths while proactively addressing its identified weaknesses.

Despite the presence of opportunities, the SCS must also diligently address emerging threats that could significantly hinder its operational effectiveness. Neglecting these threats could derail the unit's progress and undermine its ability to achieve its mission objectives.

One critical threat stem from the ongoing delays in constructing additional training facilities. These delays directly impact the development of essential combat skills among soldiers, such as marksmanship, tactical maneuvers, and physical fitness. Consequently, this hinders their combat readiness and significantly increase their vulnerability in real-world operational scenarios.

Furthermore, inadequate training funding poses a significant challenge. The current per capita allocation for trainees is sufficient to cover the escalating costs of training materials, often necessitating the diversion of limited Maintenance and Other Operational Expenses (MOOE) to supplement training budgets. Moreover, reliance solely on funding support from Higher Headquarters can be unpredictable and may not always be sufficient to meet all the training needs. This can to insufficient equipment maintenance and operation, potentially resulting in malfunctions during critical missions, jeopardizing the safety of personnel and the successful execution of operations. These operational shortcomings can severely erode public trust in the Armed Forces and the government's ability to effectively safeguard the nation. This erosion of public trust can harm recruitment efforts, discouraging potential candidates from pursuing a career in the military.

Proposed Unit Policy Directive

To address identified challenges and enhance training quality, a unit policy is proposed. This policy will prioritize infrastructure development by investing in the construction and renovation of modern training facilities to accommodate increased trainee capacity and optimize resource utilization. The policy will strengthen equipment management through rigorous inventory control, proactive maintenance schedules, and the implementation of clear accountability measures. Concurrently, it will emphasize proactive funding acquisition, including exploring alternative funding sources and optimizing allocation to ensure the sustainability of training programs. Finally, the policy will enhance training delivery by incorporating innovative methodologies such as technology-based simulations and aligning the curriculum with the evolving demands of modern warfare, thereby ensuring the continued development of highly skilled and combat-ready soldiers.

CONCLUSIONS

The following were the salient points based on the analysis of the findings.

1. The school's strategic recruitment of young, educated NCOs, predominantly male and married, fosters a dynamic and experienced training team. This young and knowledgeable workforce, with its blend of personal and professional experiences, positions the school to effectively train and mentor future generations of highly skilled and dedicated defenders of the nation.
2. The SCS, through its robust resources management practices, consistently demonstrates its adherence to the Training command's mantra of "Source of Army Standards". This commitment is evident in the meticulous maintenance of training facilities and the strategic allocation of resources, ensuring a conducive learning environment. Moreover, the school proactively seeks external partnerships and support from higher headquarters, reflecting a genuine dedication to providing the highest quality training to future generations of defenders.
3. Despite the school's efforts to optimize resource utilization, construction delays, and inadequate funding for maintenance significantly hinder progress. Urgent repairs are needed for existing facilities, while improper equipment handling and delayed fund releases further exacerbate these challenges, impacting the school's ability to effectively train future soldiers.
4. The Strengths, Weaknesses, Opportunities, and Threats (SWOT) analysis of SCS demonstrates commendable resource management practices, highlighted by a strong emphasis on facility maintenance, effective equipment management, and the development of its human capital. However, the SCS faces significant challenges, including construction delays, inadequate funding for training, and issues with equipment maintenance. To overcome these obstacles and ensure continued success, the SCS must proactively leverage external partnerships, address funding shortfalls, and prioritize the development and maintenance of critical training infrastructure. This strategic approach will be crucial in ensuring the continued training of highly skilled and combat-ready soldiers while maintaining public trust and confidence in the armed forces.
5. The proposed unit policy directive offers a comprehensive framework to address current training challenges and elevate training quality. This prioritizes infrastructure, equipment, funding, and delivery of training needs of highly skilled and combat-ready soldiers.

RECOMMENDATION

1. The School for Candidate Soldier (SCS) should continuously recruit seasoned non-commissioned officers (NCOs) to strengthen its lineup. Selecting the best and brightest soldiers, especially those from the field (combat units) will ensure the continuous delivery and transfer of knowledge to trainees/students.
2. The SCS should institutionalize best practices, including regular maintenance, partnerships with other agencies, and assigning qualified personnel for equipment management. Continuous fund requests to Higher Headquarters, coupled with rigorous financial monitoring and exploration of digital platforms for improved communication, are crucial for ensuring adequate resource allocation and timely maintenance.
3. The SCS action plan should include facility repairs, regular equipment inventories, and comprehensive troop information and education on proper equipment usage and storage. To expedite fund releases, complete documentation for all funding requests must be ensured. These measures will enhance resource management and minimize equipment damage, ensuring optimal training conditions for all trainees.
4. Having several strengths, SCS is encouraged to continuously innovate and find ways to strengthen its strengths while striving hard to address the weaknesses and transform them into strengths. Also, capitalized on the opportunities to improve the school's training facilities. Instigate ways to control the threats that can hinder the resource management process.
5. The SCS should implement the proposed unit policy, incorporating best practices and strategies for addressing identified challenges. Regularly disseminate this policy through weekly conferences and troop information and education sessions to ensure all personnel are well-informed and actively participate in its implementation.

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RANKING OF EFFECTIVE TECHNOLOGIES FROM OPTIMAL TO SUBOPTIMAL FOR MARITIME SECURITY: A MULTI-CRITERIA ANALYSIS ASSESSMENT OF THE PHILIPPINE COAST GUARD'S TECHNOLOGY SYSTEMS

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ABSTRACT

This study discusses the performance status of the Philippine Coast Guard's technology systems for maritime security by ranking them from optimal to suboptimal based on technology area criteria. In addition, the percentage of AI-based systems compared to manual systems has also been examined. Through a multi-criteria analysis, the best technologies identified are Time Zero, a software for maritime navigation that provides mapping, navigation, and land information while supporting maritime surveillance monitoring; UAV technology (Unmanned Aerial Vehicle); SONAR, which uses the propagation of sound for navigation; and RCWS (Remote-Controlled Weapon System), which allows operators to control the system from remote locations. The RCWS can be used on various platforms, including ground mobile units and naval vessels. These technologies ranked 1st, 2nd, 3rd, and 4th, respectively. These technologies play an important role in maritime security and are vital assets for the missions of the PCG. Meanwhile, RDSC (Rapidly Deployable Surveillance Camera) and LRIT (Long-Range Identification and Tracking) are at the suboptimal level and require further studies and enhancements to reach their full capacity, ranking 14th and 15th. The PCG's technology systems consist of 49.28% AI-based systems and 50.72% manual systems, indicating a gradual transition toward AI capabilities.

This paper represents the author's opinion and does not represent the views of the National Defence College of the Philippines or the Department of National Defense. The research was first presented at the 3rd International Research Conference in Sports, Education, and Sciences (3rd IRCISES) December 14, 2024 in Baguio City, Philippines. This study does not seek to redefine or go beyond the Department of Transportation's (DOTr) authority over the Philippine Coast Guard but rather aims to promote an academic perspective and discussion on the topic.

Keywords: Technology, Philippine Coast Guard, Artificial Intelligence, Maritime Borders, Technology areas

INTRODUCTION

The Philippine Archipelago and Maritime Security

Being an archipelagic nation and due to the various uses of the sea, the Philippines is confronted with various maritime issues, such as resource management, maritime borders, and sovereignty (Palma, 2009). Maritime security threats that need to be resolved include illegal migration, oil smuggling, piracy, drug trafficking, and arms trafficking (Palma, 2009). The volume and frequency of oil spills matters in relation to the economic and transport conditions within the maritime area are confronted with issues (Alea et. al., 2022). Security capacities to defend the Philippine Rise, backdoors in the south, and Malampaya are lacking (Rafal, 2024). Military hardware and corresponding equipment fundings need to be further augmented to enhance deterrence against potential incursions and terror attacks (Rafal, 2024). Enhancing systematic occurrences of oil spills is needed for the enhancement of environmental risk mitigation (Alea et. al., 2022).

In the research of Palma (2009) showed that being archipelagic country the Philippines is faced with several maritime challenges. Palma (2009), Aleah et. Al., (2022), Rafal (2024) indicated that there are

several threats the Philippines had to deal with regards to maritime security. The study of Rafal in 2024 showed that additional funding for military hardware is needed to address these issues.

A need for the assessment evaluation of the Philippine Coast Guard's technological systems' performance and status will be able to address maritime security concerns.

Technological Developments and Security, and the Philippine Coast Guard

Using its Port State Control (PSC), the Philippine Coast Guard (PCG) is the nation's front-line defense against the entry of illegal foreign vessels. The PCG is now spread across the archipelago, with 14 PSC Centers and 29 PSC Divisions. The PSC Center in Manila conducts most of its inspections based on the number of visits by foreign ships. Being vested with regulatory powers, Republic Act 9993 mandates it to comply with all national laws, treaties, or international marine agreements to which the government is a party. The "Maritime Safety (MARSAF)" function is designed to minimize or eliminate unnecessary loss of life and property at sea. In reality, every vessel leaving a port is guaranteed to be seaworthy by the additional Mandatory Pre-departure Inspection, including, without limitation, the application and enforcement of the navigational regulations, establishment of sea lanes, emergency readiness evaluation and operational readiness evaluation at the ports randomly, regular vessel safety inspection, and publishing notice to mariners (NOTAM). Additionally, the PCG is in charge of overseeing all maritime salvage operations and issuing permits, as well as dismantling or towing floating hazards that may affect navigation, including, but not limited to, illicit fish traps and vessels. Furthermore, the nation's 565 lighthouses and more than 44 navigational buoys, which direct and guarantee a safe voyage for mariners, are operated, maintained, and serviced to ensure navigational safety (Philippine Coast Guard Official Website, n.d.).

According to the Center for a New American Security, technological developments, including artificial intelligence, cyber-physical systems, information technology, autonomous technology, and many others, are fundamentally altering the face of national security. There have been many advancements concerning artificial intelligence, cyber-physical systems, information technology, and autonomous technology. The Philippine Coast Guard (PCG) serves as a frontline defense against the entry of foreign entities. The PCG is also in charge of overseeing all maritime salvage operations, issuing permits, and dismantling or towing floating hazards to navigation, among other responsibilities. In addition to protecting the country from foreign vessels entering the Philippines, the PCG has many other functions.

Savitz et al. (2020) discussed perspectives from the Evergreen Pinecone workshop regarding future threats to the Marine Transportation System (MTS). With 70 participants, including the Coast Guard, in conjunction with the annual Maritime Risk Symposium, the discussion revealed several implications for MTS related to autonomous systems such as the differential pacing of technological adoption, which placed the agency at a disadvantaged position in the maritime context where illicit and private agencies will be acquiring more superior technologies. Workforce Competency: It would, on the other hand become hard to retain and to recruit highly skilled people into service as technology becomes improved. Additionally, uncertainty of capacity demands across the MTS has been another issue of uncertainty about how government agencies might respond to the pace with which technology is changing and with respect to maritime security, unmanned autonomous systems are now being used by criminals for activities such as monitoring or bypassing law enforcement agencies in which these systems cannot easily be stopped by electronic or physical methods to determine who is controlling them unless they are captured and with the advancement of technology, smugglers can use these unmanned vehicles for their own advantage, such as gathering information or disrupting coast guard operations by blocking signals or creating distractions. Multi-domain autonomous operations, which previously focused largely on the air domain, are now increasingly being applied on and under water, as well as on land, allowing these systems to operate across different domains.

The Philippine Coast Guard's Challenges

Given the emergence of new security threats for maritime security, there is a call for more extensive analysis on the technological advancements of the Philippine Coast Guard. In line with this, this study will evaluate the current systems of technology employed by the Coast Guard, such as Automated Border Control, Maritime Domain Awareness, Machine Learning Optimization, Surveillance Towers, Heterogeneous Robotic Systems, Small Unmanned Aerial Systems (sUAS), Predictive Asset Maintenance, Object Recognition, and Geospatial Data Analytics. These technologies assist in enhancing the monitor-

ing and response capabilities, but the criminals are also using these technologies. For example, smugglers may use Geospatial Data Analytics to discover security gaps or disrupt operations through Small Unmanned Aerial Systems. Therefore, with increased technological advancement, there is an increasing need for enhancing the PCG's systems to be on top of the threats and enhance the the nation's maritime security. The study evaluates how well the technological systems of the PCG secure the country's maritime borders. Using multi-criteria decision analysis, it evaluates the performance of these technologies as optimal to suboptimal and identifies areas that need improvement. The goal is to lay a foundation for future research and projects that will push these technologies forward and strengthen the capacity of the PCG to secure the country's territorial sea and address any security threats that may arise. This research will be used as an input for future projects that might intensify the capability of the Philippine Coast Guard to ensure maritime security.

This will serve as a basis for future projects and research that may enhance the ability of the Philippine Coast Guard to safeguard the waters that are within the jurisdiction of the Philippines and the maritime security of the country.

STATEMENT OF THE PROBLEMS

Ranking of effective technologies from optimal to suboptimal for securing Philippine sea borders: a multi-criteria analysis assessment of the Philippine Coast Guard's technology systems. The specific problems are as follows:

1. What are the current technology systems being used by the Philippine Coast Guard to secure its territorial sea borders?
2. What percentage of the technology systems are used by the Philippine Coast Guard in terms of artificial intelligence?
3. What are the rankings of the technology systems used by the Philippine Coast Guard to secure its territorial sea borders, from optimal to suboptimal, based on the criteria such as automated border control, maritime domain awareness, machine learning optimization, surveillance towers, heterogeneous robotic systems, small unmanned aircraft systems (sUAS), predictive asset maintenance, object recognition, and geospatial data analytics?
4. How technology areas rank do based on technology systems?

METHODOLOGY

This section puts forth the study in terms of how it was carried out through the application of MCA or Multi-Criteria Analysis in relations to assessments of PCG's technology systems with the use of technology area criterias such as Automated Border Control, Maritime Domain Awareness, Machine Learning Optimization, Surveillance Towers, Heterogeneous Robotic Systems, Small Unmanned Aerial Systems (sUAS), Predictive Asset Maintenance, Object Recognition, and Geospatial Data Analytics. The aim is to determine the Philippine Coast Guard’s technology systems ranking and technology areas ranking from optimal to sub-optimal in order to assess the current status of the institution.

Theoretical Framework

Multi-Criteria Decision Analysis and the Weighted Additive Model

Dean (2022), in his paper titled "A Practical Guide to Multi-Criteria Analysis," defines Multi-Criteria Analysis (MCA) as "comprising various classes of methods, techniques, and tools, with different degrees of complexity, that explicitly consider multiple objectives and criteria (or attributes) in decision-making problems." One form of formula type of multi-attribute utility function is WAM or the Weighted Additive Model, as follows:

$U(a) = w1u1(a) + w2u2(a) + w3u3(a).$

Other types of Multi-Attribute Utility Functions, such as the Multiplicative Model, Quasi-Additive Model, Bilateral Model, Quasi-Pyramid Model, Semi-Cubic Model, and Multi-Linear Model in which all three criteria representations. The different models are supported by Zeleny's (1982) study. Regarding performance tables, as illustrated in Table 1, each row contains a criterion, with weights and option

performance scores. The results of the total weighted scores are used to determine the best options. Kozlowska (2022), in her study titled "Methods of Multi-Criteria Analysis in Technology Selection and Technology Assessment: A Systematic Literature Review," showed a growing trend in applying Multi-Criteria Analysis to technology assessment and selection problems. There is growing interest in this emerging field of research, particularly concerning Multi-Criteria Analysis. The Health Care Sciences category accounted for the largest share of examined documents in the Web of Science database, while in the Scopus database, most extracted documents were classified under Engineering.

Table 1: Types of Multi-Attribute Utility Functions

Types Of Multi-Attribute Utility Function	Three-Criterion Representations
Weighted Additive Model	$U(a) = w_1u_1(a) + w_2u_2(a) + w_3u_3(a)$
Multiplicative Model	$U(a) = w_1u_1(a) + w_2u_2(a) + w_3u_3(a) + kw_1w_2u_1(a)u_2(a) + kw_1w_3u_1(a)u_3(a) + kw_2w_3u_2(a)u_3(a) + k^2w_1w_2w_3u_1(a)u_2(a)u_3(a)$ With k scaling factor
Quasi-Additive Model	$U(a) = w_1u_1(a) + w_2u_2(a) + w_3u_3(a) + w_{12}u_1(a)u_2(a) + w_{13}u_1(a)u_3(a) + w_{23}u_2(a)u_3(a) + w_{123}u_1(a)u_2(a)u_3(a)$
Bilateral Model	$U(a) = w_1u_1(a) + w_2u_2(a) + w_3u_3(a) + w_{12}f_1(a)f_2(a) + w_{13}f_1(a)f_3(a) + w_{23}f_2(a)f_3(a) + w_{123}f_1(a)f_2(a)f_3(a)$ With $f_i(a)$ normalised utility difference functions
Quasi-pyramid Model	$U(a) = w_1u_1(a) + w_2u_2(a) + w_3u_3(a) + w_{12}u_{12}(a) + w_{13}u_{13}(a) + w_{23}u_{23}(a) + w_{123}u_1(a)u_2(a)u_3(a)$
Semi-cubic Model	$U(a) = w_1u_1(a) + w_2u_2(a) + w_3u_3(a) + w_{12}u_{12}(a) + w_{13}u_{13}(a) + w_{23}u_{23}(a) + w_{123}f_1(a)f_2(a)f_3(a)$ With $f_i(a)$ normalised utility difference functions
Multi-linear Model	$U(a) = w_1u_1(a) + w_2u_2(a) + w_3u_3(a) + w_{12}w_1w_2u_1(a)u_2(a) + w_{13}w_1w_3u_1(a)u_3(a) + w_{23}w_2w_3u_2(a)u_3(a) + w_{123}w_1w_2w_3u_1(a)u_2(a)u_3(a)$

Source: Adapted from Zeleny (1982).

Procedure

The goal is to acquire knowledge about the various technologies employed by the Philippine Coast Guard, particularly by comparing AI-equipped technologies with manual ones. This will involve conducting interviews and surveys to assess the effectiveness and efficiency of these technologies.

The PCG personnel sample size to be surveyed is 34, using purposive sampling. The respondents were selected on the basis of their position as users of technology systems to ensure relevance to the objectives of the study and to improve the validity and reliability of the data.

The surveys via the use of Google Forms assisted the researcher in order to have data gathering in terms of effectiveness of different technologies via scoring system, provided insights and information also if the technologies were AI or manually equipped. Multi-Criteria Analysis (MCA) was utilized in order to rank the technologies, in terms of highest ranks being considered as optimal while the lowest ranks deemed to be as sub-optimal, allowing for a clearer understanding of their overall performance.

The criteria used were based on the study by Silversten et al. (2021) from RAND Europe regarding border and coast guard applications (see table 2).

Data gathering was conducted through interviews via Google survey forms concerning the different technologies being used by the Philippine Coast Guard (PCG). The PCG interviewees gave scores with respect to the technologies being used by the PCG on a scale from 1 to 4 (see figure 1)

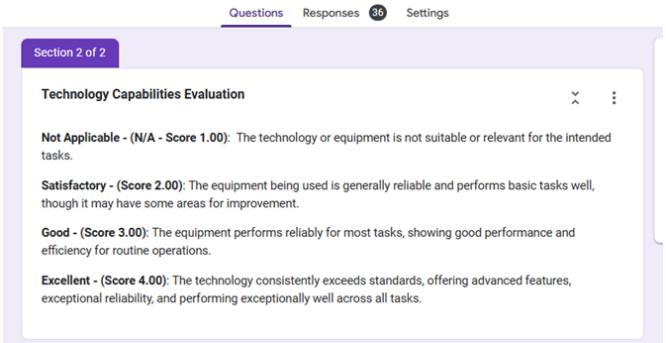

Figure 1 Survey Technology Score Scales

Weights were assigned equally at 11.11% with respect to criteria such as Automated Border Control, Maritime Domain Awareness, Machine Learning Optimization, Surveillance Towers, Heterogeneous Robotic Systems, Small Unmanned Aircraft Systems (sUAS), Predictive Asset Maintenance, Object Recognition, and Geospatial Data Analytics. Using the Simple Additive Weighting (SAW) method in which this formula will be employed in order to calculate the scores for each technology, representing their effectiveness in meeting the defined criteria.

The formula SAW was applied to each technology (a,... n) and all the collected data were be computed using Multi-Criteria Analysis via the formula:

Sa= (Wabc)(Sabc)a + (Wmda)(Smda)a + (Wmlo)(Smlo)a + (Wst)(Sst)a + (Whrs)(Shrs)a
+ (Wsua)(Ssua)a + (Wpam)(Spam)a + (Wor)(Sor)a + (Wgda)(Sgda)a
Sn= (Wabc)(Sabc)n + (Wmda)(Smda)n + (Wmlo)(Smlo)n + (Wst)(Sst)n + (Whrs)(Shrs)n
+ (Wsua)(Ssua)n + (Wpam)(Spam)n + (Wor)(Sor)n + (Wgda)(Sgda)n

Where:

Sa, and Sn = the final scores of techonology systems

Wabc, Wmda, Wmlo, Wst, Whrs, Wsuas, Wpam, Wor, Wgda = the weights assigned to criterias such as automated border control, Maritime domain awareness, machine learning optimization, surveillance towers, heterogeneous robotic systems, small unmanned aircraft systems, Predictive asset maintenance, object recognition, geospatial data analytics) in the evaluation process in which the weights reflect the relative importance of each criterion in the decision-making process.

Sabc, Smda, Smlo, Sst, Shrs, Ssua, Spam, Sor, Sgda = the scores achieved by each alternative technology with respect to the corresponding criteria.

Technologies Ranking from the Optimal to the Sub-optimal:

Ranking the technologies used by the Philippine Coast Guard was an activity towards maximizing resource utilization efficiency as well as ensuring optimal effectiveness in operation. It was done through multi-criteria analysis to assess how each of its technologies performs well so that the ones having the greatest impact could be pinpointed.

Ranking-based total weighted score categorizations included the following: Sub-optimal technologies were categorized in a total weighted score of 1.00 to 1.99, which signified that these were not efficient and needed for further improvements, Mid-optimal technologies range from 2.00 to 2.99, technologies that showed efficiency in performed tasks, but still needed for potential improvements Lastly, Optimal technologies between 3.00 to 4.00 point levels in which technologies with excellent performance on any tasks. Such ranking, based on performance were categorized in a transparent and systematic way..

Technology Area Criteria ranking

After determining the rankings of different technologies, the researcher assessed the rankings of specific criteria such as Automated Border Control, Maritime Domain Awareness, Machine Learning Optimization, Surveillance Towers, Heterogeneous Robotic Systems, Small Unmanned Aircraft Systems, Predictive Asset Maintenance, Object Recognition, and Geospatial Data Analytics to identify areas that required improvements. Furthermore, the researcher analyzed the proportion of AI-equipped systems compared to manually operated systems within the technologies employed by the Philippine Coast Guard (PCG).

Using the following formula:

S_abc = Tech 1 @ C_abc + Tech 2 @ C_abc + … Tech nth @ C_abc
S_mda = Tech 1 @ C_mda + Tech 2 @ C_mda + … Tech nth @ C_mda
S_mlo = Tech 1 @ C_mlo + Tech 2 @ C_mlo + … Tech nth @ C_mlo
S_st = Tech 1 @ C_st + Tech 2 @ C_st + … Tech nth @ C_st
S_hrs = Tech 1 @ C_hrs + Tech 2 @ C_hrs + … Tech nth @ C_hrs
S_suas = Tech 1 @ C_suas + Tech 2 @ C_suas + … Tech nth @ C_suas
S_pam = Tech 1 @ C_pam + Tech 2 @ C_pam + … Tech nth @ C_pam
S_or = Tech 1 @ C_or + Tech 2 @ C_or + … Tech nth @ C_or
S_gda = Tech 1 @ C_gda + Tech 2 @ C_gda + … Tech nth @ C_gda

Where: S_abc, S_mda, S_mlo, S_st, S_hrs, S_suas, S_pam, S_or, S_gda represent the total score for each criterion: (abc) Automated Border Control, (mda) Maritime Domain Awareness, (mlo) Machine Learning Optimization, (st) Surveillance Towers, (hrs) Heterogeneous Robotic Systems, (suas) Small

Unmanned Aircraft Systems, (pam) Predictive Asset Maintenance, (or) Object Recognition, and (gda) Geospatial Data Analytics. These various technologies are represented by the different technical capabilities of the PCG, from Tech 1 to Tech nth. With this, it provides for a holistic review of these technologies and criteria so that informed decisions can be made that can help utilize prioritized resources that may advance more the operational capability and effectiveness of the Philippine Coast Guard.

Table 2 Technology Areas

#	Technology area	Description	Capability area	Border security function
1	Automated border control	Integrated systems of e-gate hardware, document scanning and verification, facial recognition and other biometric verification, which are used to facilitate the processing of travellers on border crossings while enhancing security through the integration of various AI-enabled tools.[37]	Access control, authentication of people and vehicles	Detection, identification and authentication
2	Maritime domain awareness	Capabilities aimed at establishing 'the effective understanding of anything associated with the global maritime domain that could impact [a country's] security, safety, economy or environment' including integrated analysis of various data streams, such as Automatic Identification Systems (AIS), coastal and vessel-mounted sensors, and contextual information concerning the weather, commercial activities, environmental conditions, military exercises and maritime incidents.[38]	Data fusion, surveillance database cross-analysis and information correlation	Information management, situation awareness & assessment
3	Machine learning optimisation	Use of AI to automate the selection, testing and optimising of Machine Learning models, a solution known as automated machine learning (AutoML). This includes the automation of all steps of ML algorithm development, from identifying the problem/process to be improved, data collection and clean-up, model development, training and evaluation.[39]	Information management automation	Information management
4	Surveillance towers	Unmanned surveillance capabilities in the form of autonomous surveillance towers fielded in border regions, integrating software and hardware surveillance capabilities, e.g. to detect illegal border crossings.[40]	Surveillance (installations)	Situation awareness & assessment
5	Heterogeneous robotic systems	A capability that integrates various unmanned systems, including vehicles of 'different sizes and abilities for maritime, land and air environments'.[41] Networked heterogeneous robotic systems may be applied to various functions, including environmental monitoring, border control and counter-terrorism.	Surveillance (autonomous systems)	Situation awareness & assessment
6	sUAS	Small autonomous unmanned aerial systems (sUAS) that may be used to perform functions such as border surveillance, environmental monitoring and disaster relief. sUAS often include integrated AI-enabled object recognition, classification and tracking capabilities.[42]	Surveillance (autonomous systems)	Situation awareness & assessment
7	Predictive asset maintenance	Predictive analytics enabling optimal operations and maintenance of technical systems.[43] This may enable end users to identify vulnerabilities, sub-optimal performance or potential technical failures in complex technical systems such as multi-vehicle UAS networks that are used for ground surveillance or strengthening airspace awareness.[44]	Predictive analytics	Information management
8	Object recognition	Algorithmic recognition and classification of objects through annotation, training and analysis of complex data, e.g. 3D imagery. Object detection and recognition systems are extensively utilised to perform functions including detection of suspicious packages, vehicles and cargo.	Threat detection, information management automation	Detection, identification and authentication, information management
9	Geospatial data analytics	Use of AI to analyse geospatial data, including labelling and classification of satellite imagery. Geospatial data analytics may support operational awareness and threat detection.[45]	Information management automation	Information management

Source: RAND Europe analysis.

FINDINGS

The PCG employs technology systems with manual and AI capabilities for safeguarding the Philippines' territorial sea borders. One such example is the Remote Controlled Weapon System (RCWS). The RCWS can be used on various platforms, including ground mobile or stationary units and naval vessels, without exposing the operator to risk and this system can be installed on any support platform, tank, or armored vehicle (Elbit Systems, n.d.). Another technology deployed by the PCG is RADAR. The RADAR aids in the identification, tracking, and positioning of vessels and thus helps the PCG in navigation (Marine Insight, n.d.). Also, there is the Automatic Identification System (AIS). The AIS automatically monitors other vessels in the area via the usage of the Very High Frequency VHF maritime band (Bhattacharjee, 2024). PCG also uses the Long Range Identification and Tracking with (LRIT) system for international identification and tracking of ships. LRIT provides enhanced security and protection of the marine environment (IMO, n.d.).

With regard to surveillance, the PCG employs the Rapidly Deployable Surveillance Camera (RDSC). NAVTEX is another technology used by the PCG. The NAVTEX automatically broadcasts information such as navigational dangers and missing vessel warnings in terms of safety (Mukherjee, 2021). Furthermore, the PCG uses UAVs and body-worn cameras.

The PCG also employs Sound Navigation and Ranging (SONAR) technology, which uses sound propagation for navigation, establishing reliable channels of communication for maritime operations.

SONAR, like RADAR, operates on a similar principle, except that RADAR uses radio waves in the atmosphere while SONAR uses sound waves. In terms of propagation, sound waves are much more effective in underwater environments (Bryant, n.d.; Sonar & the USCG, n.d.).

In addition PCG also utilizes the Electronic Chart Display and Information System "(ECDIS)". The ECDIS is used in ships and naval operations as a navigational chart system, allowing for easy determination of locations and directions. Additionally, it has capabilities for route monitoring and planning (Bhattacharjee, 2021). The PCG also has Automatic Radar Plotting Aid (ARPA) wherein ARPA disseminates calculations and radar charts to radar operators, which is efficient in saving time by automating tasks such as target identification and data analysis (An Introduction to Radar Watchkeeping and SOLAS Requirements for Radars Ships, 2019).

PCG uses TIMEZERO tools. TIMEZERO is a maritime navigation software solution that enables insights into navigation and mapping, including satellite photos, land information, and support for coastal monitoring through maritime surveillance and other features (TIMEZERO | Marine Navigation Software, n.d.). PCG also uses other modes of communication systems like VHF and High Frequency HF base radios.

Altogether, these technologies bring about strength to the efforts of the PCG in securing the safety and security of the nation's waters, thus perfecting its core functions and quick response to emergencies (see table 3).

Table 3. The Philippine Coast Guard's Technology Systems
(Philippine Coast Guard, 2024)

Philippine Coast Guard's Technology Systems		
REMOTE CONTROLLED WEAPON SYSTEM (RCWS)	UNMANNED AERIAL VEHICLE	AUTOMATIC RADAR PLOTTING AID
RADAR	BODY WORN CAMERA	NARROW BAND DIRECT PRINTING
AUTOMATIC IDENTIFICATION SYSTEM	SOUND NAVIGATION AND RANGING	TIME ZERO
RADIO COMMUNICATION SYSTEM	MONITORING SYSTEMS	LONG RANGE IDENTIFICATION AND TRACKING
RAPIDLY DEPLOYABLE SURVEILLANCE CAMERA	ELECTRONIC CHART DISPLAY INFORMATION SYSTEM	
NAVIGATIONAL TELEX		

The ranks of the current technology systems being used from optimal to suboptimal by the Philippine Coast Guard with regards to securing its territorial sea borders

The ranks of the current technology systems being used by the Philippine Coast Guard, from optimal to suboptimal, with regard to securing its territorial sea borders, have been established. After calculations using the Multi-Criteria Analysis, the TIMEZERO technology received the highest weighted score and is classified as the optimal technology used by the Philippine Coast Guard, holding Rank 1. This is followed by UAV, SONAR, and RCWS, which occupy the second, third, and fourth ranks, respectively, under the optimal category, with total weighted scores of 3.99, 3.16, 3.11, and 3.08. As far as the ranking results of the PCG's technologies are concerned, the optimal technologies include TIMEZERO, UAVs, SONAR, and RCWS.These technologies greatly covered the security of the territorial sea. These technologies play vital roles in marine navigation and mapping, aerial surveillance, maritime communications, and remotely controlled weapon technologies.

Based on the Taxonomy of current and potential uses of AI in border security by RAND Europe, TIMEZERO and SONAR function can be considered part of information management border security tools, due to the fact that TIMEZERO has capabilities of data handling, like satellite pictures, and maritime surveillance and the SONAR handles data collected from sound waves given out by some objects. On the other hand, RCWS and UAVs fall under situation awareness and assessment for border security as their function because UAVs have capabilities for surveillance and can function as autonomous systems, while RCWS are equipped with weapons for deployment and cameras for surveillance capabilities.

The suboptimal category includes the RDSC, which ranked 14th with a total weighted score of 1.93, and for 15th place is the LRIT, both of which have weighted scores of 1.77. The complete list of rankings, scores, and corresponding categories can be seen in Table 4.

Referring to the Taxonomy of current and potential uses of AI in border security by RAND Europe, it shows that RDSC falls under the umbrella of situation awareness and assessment as a border security function because RDSC has capabilities for surveillance, including people, vehicles, and other types of

objects, as well as detection, identification, and authentication functions. It also has capabilities for vessel identification. LRIT falls under detection, identification, and authentication border security functions due to its capacity to collect and transmit information about vessels' positions and identities for tracking and verification.

The strengths of technologies like TIMEZERO, UAVs, SONAR, and RCWS underscore the PCG's capabilities in information management and situation awareness and assessment. These capabilities fall under the umbrella of the maritime domain awareness technology area, which is a key criterion used in the Multi-Criteria Analysis (MCA) formula.

The two technologies to be improved are the RDSC and LRIT. The RDSC, which supports situational awareness and assessment, is associated with technology criteria such as maritime domain awareness, surveillance towers, heterogeneous robotic systems, and small autonomous unmanned aerial systems (sUAS). With respect to LRIT, with capabilities such as detection, identification, and authentication, the LRIT is associated with technology criteria like automated border control and object recognition. For future projects with respect to RDSC may explore research projects in relations to maritime domain awareness, surveillance towers, heterogeneous robotic systems, and small autonomous unmanned aerial systems (sUAS) while LRIT may explore future research projects in relations to automated border control and object recognition.

AI technologies Compared to Manual Technologies within the Philippine Coast Guard in Percentage

About 49.28% of the total technology in the PCG is AI-enabled, while the major technologies are still in manual mode at 50.72%. The use of AI by the PCG in almost 49.28% of its technologies is a giant leap for the adoption of advanced tools. The remaining 50.72% is still run on a manual basis; the PCG is thus assimilating the most modern AI technologies while using most of the traditional ones at the same time. The balance will be toward maximizing efficiency using AI, with the benefit of maintaining performance based on trusted systems. The PCG exhibits flexibility in adapting to the advanced technology such as AI but still have the core competence of the manual-based operation.

Table 4 Technology Rankings With Weighted Scores and their Categories

CATEGORY	RANK	TECHNOLOGIES	WEIGHTED SCORES
OPTIMAL	1	Time Zero	3.99
OPTIMAL	2	Unmanned Aerial Vehicle (UAV)	3.16
OPTIMAL	3	Sound Navigation and Ranging (SONAR)	3.11
OPTIMAL	4	Remote Controlled Weapon System (RCWS)	3.08
MID-OPTIMAL	5	Electronic Chart Display Information System (ECDIS)	2.93
MID-OPTIMAL	6	Narrow Band Direct Printing (NBDP)	2.80
MID-OPTIMAL	7	Radio Detection and Ranging (RADAR)	2.69
MID-OPTIMAL	8	Automatic Identification System (AIS)	2.67
MID-OPTIMAL	9	Body Worn Camera (BWC)	2.52
MID-OPTIMAL	10	Monitoring Systems	2.38
MID-OPTIMAL	11	Radio Communication System	2.26
MID-OPTIMAL	12	Automatic Radar Plotting Aid (ARPA)	2.22
MID-OPTIMAL	13	Navigational Telex (NAVTEX)	2.11
SUBOPTIMAL	14	Rapidly Deployable Surveillance Camera (RDSC)	1.93
SUBOPTIMAL	15	Long Range Identification and Tracking (LRIT)	1.77

Ranking of the Technology Areas (Criterion) by the Philippine Coast Guard

Analyzing a technology system, such as an Unmanned Aerial Vehicle (UAV), using weighted scores reveals variations across different criteria. This demonstrates that a given technology can be evaluated based on its functionality in relation to specific criteria. The total score for Automated Border Control criteria across different technologies can be compared to the total scores for Maritime Domain Awareness, Machine Learning Optimization, Surveillance Towers, Heterogeneous Robotic Systems, sUAS, PAM, OR, and Geospatial Data Analytics. This comparison highlights the relevance of the Philippine

Coast Guard's (PCG) technology in various technological domains. The results indicate that Maritime Domain Awareness ranks the highest (see Tables 5 and 6, and Figure 2).

The ranking of the PCG's technology systems highlights the effectiveness of its existing infrastructure. Maritime Domain Awareness, which received a total weighted score of 4.99 and ranked 1st, is the top (criterion) technology areas. This means the technology systems of the PCG deliver powerful capabilities for information gathering and analysis to shape the country's safety, economy, and security in the global maritime sphere. They combine several streams of data from sensors and the AIS in order to provide real insights.

Table 5. Unmanned Aerial Vehicle in Terms of Weighted Scores Across Different Criteria

UNMANNED AERIAL VEHICLE	
CRITERIA	WEIGHTED SCORES
Automated Border Control	0.27775
Maritime Domain Awareness	0.3333
Machine Learning Optimization	0.3333
Surveillance Towers*	0.3333
Heterogenous Robotic Systems	0.3333
Small Unmanned Aircraft Systems (SUAS) *	0.38885
Predictive Asset Maintenance	0.38885
Object Recognition	0.38885
Geospatial Data Analytics	0.38885

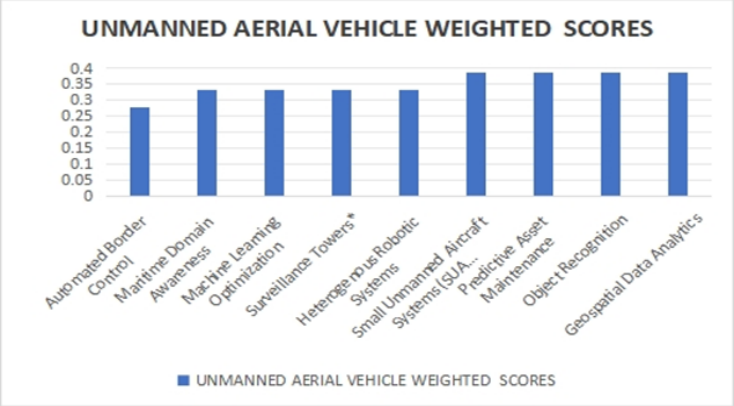

Figure 2: Graph of Unmanned Aerial Vehicle Weighted Scores Across Different Criteria

Surveillance Towers ranks 2nd with a score of 4.87, demonstrating strong capabilities in securing and monitoring maritime borders through autonomous surveillance systems. Rank 3 with a score of 4.83 is the MLO that basically automates and optimizes the use of AI in machine learning models, advancing the capabilities of the operation of PCG. Fourth rank with a score of 4.78 is the Predictive Asset Maintenance, which ensures assets owned by PCG are more durable and reliable through complex predictive analytic techniques. Finally, rank 5 is Object Recognition and rank 6 is the Small Unmanned Aircraft Systems both with scores at 4.71 and 4.64 respectively.

However, the PCG's technologies scored lower in Heterogeneous Robotic Systems, ranking 9th with a score of 4.19. This area may be applied to various functions, including environmental monitoring, border control, and counter-terrorism.

Despite that, all the criteria can stand out to meet the standards that while none of them fail, it should be further improved to increase its ranking from the least ranked. Further, other criteria should have balanced score within the effective technology of PCG in order to have an overall strong technological capability effect.

Table 6. The Rankings of Technology Areas

RANK	CRITERIA	SCORES
1	Maritime Domain Awareness	4.99
2	Surveillance Towers	4.87
3	Machine Learning Optimization	4.83
4	Predictive Asset Maintenance	4.78
5	Object Recognition	4.71
6	Small Unmanned Aircraft Systems (SUAS)	4.64
7	Automated Border Control	4.50
8	Geospatial Data Analytics	4.43
9	Heterogenous Robotic Systems	4.19

CONCLUSIONS

The study regarding the technology assessment of the PCG shows the enhancement requirements to ensure effectiveness in securing the nation's maritime borders.

1. In terms of Optimal ranks, the top-performing technology systems are the TimeZero, UAVs, SONAR, and RCWS systems, with these systems greatly protecting the security of the Philippines' territorial borders. The technologies that the Philippine Coast Guard (PCG) has employed are highly relevant to its specific tasks and have greatly contributed to addressing maritime threats. TIMEZERO has improved marine navigation and optimized routes to ensure efficient patrols and prompt responses to accidents, illegal fishing, and smuggling. UAVs allow for aerial surveillance over large areas in monitoring for piracy, smuggling, human trafficking, and environmental violations. The Sonar allows underwater detection and navigation to be possible and very essential in the discovery of submarine incursions into territorial waters and protection of maritime infrastructure. The RCWS will provide safety of PCG vessels during hostile engagements as it will have precision targeting without putting the personnel at risk. Therefore, all these technologies would heighten operational coverage, reduce the response time, enhance safety, and improve threat detection capabilities for the PCG to effectively protect the territorial waters against various threats. Technology systems under the Optimal ranks are very important to the PCG with respect to marine navigation, aerial surveillance, maritime communications, and remotely operated weaponry.
2. In terms of Suboptimal ranks, technologies like RDSC and LRIT needs enhancements or advancements in order to strengthen the Philippine coast guard's technology systems and make this systems move forward in the mid-optimal from suboptimal ranks in which the advancements will boost and improve securing borders of the Philippines.
3. In terms of AI Integration: The PCG's technology systems has 49.28% of AI-enabled systems that basically shows progress in terms of modernization, However, with 50.72% of the PCG's systems still reliant on manual systems, this basically shows that the PCG has great skills regarding how to balance the AI advanced technology systems with traditional manual technologies, in other words, the PCG has the adapting skills because they can manage AI with manual systems and even though they still uses manual systems, they can still manage modern technology with manual systems without sacrificing reliability and in addendum it basically shows that they are already ready for future modernization.
4. In terms of technology areas, the PCG's Maritime Domain Awareness ranked as no. 1 which presents that the PCG has the capabilities in terms of data gathering and analysis that has great impact with respect to economy, security, and safety in the global maritime sphere. Technology systems under Maritime Domain Awareness have capabilities of multiple data streams in order to provide comprehensive insight with the assistance of sensors and the AIS.

This conclusion shows that the PCG is already prepared for enhanced technology systems integration while identifying areas needing attention for a balanced and modernized approach to maritime security.

RECOMMENDATIONS

1. RDSC, a Rapidly Deployable Surveillance Camera, and LRIT, a communication system already used by the PCG for tracking and identifying vessels. Tracking and surveillance could be further enhanced by investing in underwater drones. These drones would allow the PCG to track suspected underwater activity and monitor sunken vessels that cause oil spills, supplementing its current tracking capabilities. LRIT and RDSC, together with underwater drones, would strengthen the PCG's maritime security operations by enabling it to monitor both surface vessels and underwater threats. Investing in these technologies would contribute to the overall development of the PCG's technological systems and further enhance maritime security.
2. In terms of AI, the PCG may consider researching and developing projects that incorporate AI into their manual systems to optimize operations, marking a step toward full modernization.
3. Regarding suboptimal areas of technology, such as heterogeneous robotic systems, to create a better and well-coordinated technological system within the PCG's technology, the PCG can purchase a Remotely Operated Vehicle (ROV) like Hakuyo from Japan. The ROV helped the PCG locate the MT Princess Empress, which leaked a vast quantity of oil. This purchase would be an excellent addition to enhancing the PCG's ability to respond to oil spills efficiently. The PCG may also consider researching or investing in underwater anti-drone systems, which could help prevent the entry of unauthorized underwater drones into the nation's maritime borders.
4. Continuous research, collaboration, and technology transfer would be essential in accelerating technological advancements.
5. To give a robust and future-proof maritime security system, the PCG must be proactive by upgrading its existing technologies and filling gaps in suboptimal areas. Upgrading LRIT and RDSC with underwater drones and acquiring heterogeneous robotic systems like ROVs for environmental protection can make the PCG's surveillance and response capacities much stronger. Aside from that, the investment in underwater anti-drone technologies will make the nation's defense capabilities stronger against such future threats. Sustained research, alliances, and transfer of technology shall be strategic orientations towards closing knowledge gaps and ensuring that the PCG keeps abreast of breakthroughs in maritime security. Addressing gaps in suboptimal technologies will also optimize the capabilities of optimal ones, producing a more integrated and robust technological system that is best positioned to protect the nation's maritime security.

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EMPLOYABILITY OF THE K TO 12 2018 HOME ECONOMIC GRADUATES OF NATIONAL HIGH SCHOOLS OF DISTRICT 1 IN IFUGAO

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ABSTRACT

The establishment of Senior High school program of the Philippines has put technical- Vocational Education in the limelight. The offering of Tech-Voc Education in various schools is aimed at equipping the student with skills and knowledge needed should they choose middle-level employment after graduation. This study aims to determine the employability of graduates for effective implementation of the program amid the challenges. This descriptive study presents the Employability of the Batch 2018 Home Economic Graduates of National High schools of District 1 in Ifugao. Questionnaires were used to gather data in national high schools of District 1. In terms of the employability of TVL graduates, the results showed that few of the respondents are earning meager amount and satisfied while some are not satisfied. Due to mismatch, there is less employment of the skills because most of the respondents did not continue developing their skills by continuing their strand but rather, they ventured into unrelated courses when they entered college. Most are not competent.

Keywords: Development, Effectiveness, Technical-Vocational Livelihood, K to 12, Graduates

INTRODUCTION

Employability is defined as an individual's ability to enter, adapt to, and excel in the workforce (Tentama & Yusantri, 2020). This concept is crucial for entrepreneurial intentions, as strong skills enhance access to the job market. Additionally, acquiring essential skills is vital for individual success and economic growth, as noted by KRE Okoye (2015). Home Economics education advocates for positive change in home life experiences for individuals and families. It is the foundation of knowledge, attitudes and abilities that affect daily decision making throughout our lives. Home economics has five interdependent areas: human development, food and nutrition, financial management, clothing and textiles and shelter and housing.

The primary objective of the senior high school is to effectively prepare students for the workforce, particularly those in the Technical-Vocational and Livelihood (TVL) track, or to continue their education in college. TVL graduates are expected to possess job-specific skills and are legally eligible for employment upon graduation. This would help decrease the youth unemployment rate of 13.1% in 2016 as reported by the International Labor Organization (ILO).

The Philippines has decisively implemented the K to 12 programs in its education system, transitioning from a traditional four-year high school curriculum to a comprehensive six-year program that includes an additional two years of senior high school. Starting in the 2012-2013 school year, the Philippines upgraded its education system from ten to twelve years through the K-12 Education Plan, initiated by the Department of Education (Hubpages Inc., 2016).This program is crucial for ensuring high school graduates are employable and economically productive, even without a college degree (Sunstar, 2015). The shift to K-12 compulsory education has significantly improved employment rates, largely due to Technical Vocational Education and Training (TVET) programs, such as Home Economics, which equip graduates with essential job skills without the need for a college degree. Despite the belief in the effectiveness of Technical and Vocational Education and Training (TVET) for improving graduate employability, many technical high school graduates still face underemployment, low-quality jobs, and total un-

employment. This situation highlights the urgent need to reassess whether formal education is meeting the demands of the 21st-century labor market.

Moreover, with the integration of TVET into the newly implemented K-12 education system, graduates are better positioned with the skills necessary for today's job market. Many students opting out of higher education can obtain a National Certificate (NC) from TESDA, which is crucial for employment locally and internationally (Kiran S. Budhrani et al., 2017). De Largentaye asserts that TVET is a definitive solution to employability issues. By imparting essential and transferable skills—such as teamwork, problem-solving, and communication—TVET prepares graduates to thrive in a rapidly evolving knowledge-based economy, as noted by UNESCO and the OECD.

Furthermore, studies in Ethiopia and the Netherlands show alarmingly low employment rates for vocational students, particularly in the garments sector. In the U.S., the lack of mandatory certification makes TVET programs ineffective. In the Philippines, high dropout rates and youth unemployment have driven the implementation of the K-12 education system to produce more employable graduates. A total of 269 employed TVL graduates were surveyed. The study concludes that mismatch between job and skill is highly evident. The findings serve as basis in the creation of intervention initiatives that will improve the implementation of the TVL program (Autentico, J.M, & Alerta, G.). To fully evaluate the impact of the TVET program in the implemented K-12 education system, it is essential to track the employability of K-12 Home Economics graduates in public schools. Action must be taken now to ensure vocational graduates continue developing their skills in the workforce.

STATEMENT OF THE PROBLEM

This research aims to determine the Employability of the K to 12 Home Economic Graduates of National High Schools of 2018 in the 1st district of Ifugao.

Specifically, this research seeks to answer the following questions:

1. What is the profile of the respondents in terms of:
   1.1 age;
   1.2 sex; and
   1.3 civil status
2. What is the employment status of K to 12 Home Economics Graduates in terms of income-generating activity and monthly income?
3. How did the respondents continue developing their home economics skills?
4. How satisfied are the respondents in their employment utilizing their home economic skills?

Research Methods

This study employs quantitative research, utilizing a questionnaire as the primary data-gathering tool. It includes a survey and follow-up interviews to assess the employment of K to 12 Home Economics graduates from 2018. According to V. Preston in the International Encyclopedia of Human Geography (2009), survey questionnaires are essential for gathering precise statistical information about a population's characteristics through standardized questions.

The effectiveness of a questionnaire relies on the relevance of the information sought and the respondents' ability to provide informed answers. Since this study aims to evaluate the technical vocational skills of the 2018 National High School graduates in District 1, the survey method is the most appropriate choice.

Research Environment

This study was conducted in the municipality of Lamut and Hungduan within the province of Ifugao, two of the six provinces of the Cordillera Administrative Region (Region CAR) located in the Central Northern Luzon of the Philippines. More specifically, the study was conducted in Ifugao Technical Vocational High School formerly Hapid National High School-Annex in Bimpal, Lamut, Ifugao, and Bangbang National High School in the municipality of Hungduan, this year 2021-2022.

The municipality of Lamut is one among the 11 municipalities of the province of Ifugao and it is composed of 18 barangays. It is located in the South-eastern portion of the province and is known to be the gateway to the famous Banaue Rice Terraces which is about 50 km drive away and 27 km to Laga-

we, the Capital Town. During the early 19th century, Lamut is a barrio of Kiangan municipality in the old Mt. Province. Ilocano settlers from Nueva Vizcaya and the Ilocos provinces first occupied the place that was then known as Mabatobato, a rich pasture land. The settlers were attracted to the place due to its proximity to the Lamut River and the abundance of wildlife. It was because of the abundance of food that the place was later called Lamut, which means food in the Ilocano dialect.

The municipality of Hungduan, standing northwest of Banaue, carries a solemn ambiance brought about by its tame and scenic landscape. It is the home of 2000- a year-old terraces cluster that resembles a spider's web, covering tree villages separated by flowing rivers. The first of these villages is Nangulunun characterized by tall rice terraces, followed by Hapao which resembles a valley of wide rice beds. The vast landscape allows for a moderate trek and a leisurely walk on what locals call the "pilapil" or the narrow terrace path where you can also see water flowing to act as irrigation for the rice paddy. Deeper towards Hapao village, your feet take you to the Bogyah hot spring in between Hapao and Baang. With its clean waters that get warmer between 10 am 11 a.m. You also deep into the cool, flowing Hungduan river beside it for a refreshing treat. Hungduan is a municipality in the landlocked province of Ifugao and it is composed of nine barangays. It is home to the towering Mt. Napulawan, the 2nd highest peak in Ifugao with an elevation of 2,642 meters above sea level, and where tales of General Tomoyuki Yamashita "Tiger of Malaya". His treasures remain strong.

In the early times, Hungduan is the main route of travelers from other municipalities on their way to Benguet and Baguio City. The tribal Hudhud tale also often mentions Hungdu as a stopping place for travelers. It will also lead you to the ever-relaxing bogya hot and cold spring, another easy choice for soul-searchers.

Respondents

This study aims to randomly sample the employability of K to 12 Home Economics graduates from 2018 at Ifugao Technical Vocational High School (ITVHS) and Bangbang National High School. It will assess their employment status, focusing on those who are employed, unemployed, and those who have continued their education in college.

These national high schools offer technical vocational tracks in home economics, specifically in garments, cookery, carpentry, and Electrical Installation and Maintenance (EIM). Due to the pandemic situation and transportation difficulties, Tinoc National High School was not included.

Table 1. Distribution of respondents according to school offerings in Home Economics

Schools	Population	Number	Percentage
Bimpal	70	58	79%
Hungduan	16	16	21%

Table 2. Distribution of respondents according to Home Economics Specialization

H.E Specialization	Total Number of students	Number	Percentage
Garments	26	24	37%
Carpentry	11	11	5%
Electrical Installation and Maintenance	20	18	24%
Cookery	29	22	34%
Total	86	75	100%

Data Gathering Tool

This study used a survey questionnaire and follow-up interviews as the main methods for data collection. A survey questionnaire collects information from respondents and can provide both quantitative and qualitative data. While not all data collection involves surveys, every survey includes a questionnaire. Survey questions are typically straightforward and easy to understand, making it easier to compile usable data through standardized responses.

Weighted Mean and Descriptive Rating are used in describing the level of satisfaction of the respondents. Below is the interpretation guide:

Range	Level	Descriptive Rating
2.50 - 3.00	3	Highly Satisfied
1.50 - 2.49	2	Satisfied
1.00 - 1.46	1	Not Satisfied

Statistical Treatment of Data

Descriptive statistics will be used to describe the profile of the respondents. The percentage shows the tabulated Employability of the K to 12 2018 Home Economic Graduates of National High Schools of District 1 in Ifugao.

The quantitative descriptive will be used to determine the profiling of the respondents including the issues and concerns in the program.

Data Gathering Procedures

The data gathering started analyzing the document after it was presented to the research adviser. Some revisions were made and we finalized the questionnaires ready for floating.

Questionnaires were delivered via Google Forms. After the respondents submitted, we tallied the data, tabulated and subjected it to statistical treatment.

RESULTS AND DISCUSSION

This chapter presents the findings of the study organized and presented in order following the sequence of the statement of the problem presented in Chapter 1.

Part 1. Profile of the Respondent

The result shows that 40 or 58% of the respondents are between the ages of 22 and 23; 23 or 33% are 21 years of age or younger; and 6 or 9% are 24 years of age or older. This demonstrates that the Home Economics 2018 graduates are of legal age and eligible for full-time work.

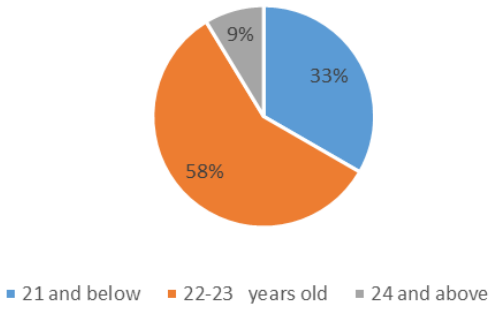

Figure 6. Frequency and Percentage distribution of the respondents according to age

As illustrated in Figure 7, 45-60% of the respondents are female, while 30-40% are male. This shows that a larger proportion of respondents is female, with fewer males participating. It suggests that fewer males enroll in Higher Education (HE) courses, as most tend to pursue academic programs. In contrast, more females opt for HE courses, particularly in fields such as culinary studies.

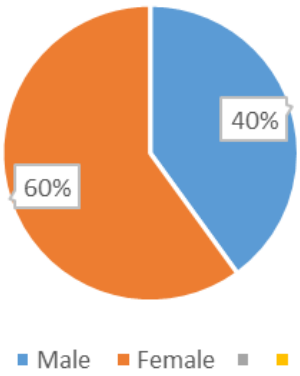

Figure 7. Frequency and Percentage distribution of the respondents according to sex

Figure 8 shows that 62-83% of the respondents are single, while 13-17% are married. This indicates that the majority of the respondents are still single and likely college students, with fewer choosing to settle down and start businesses.

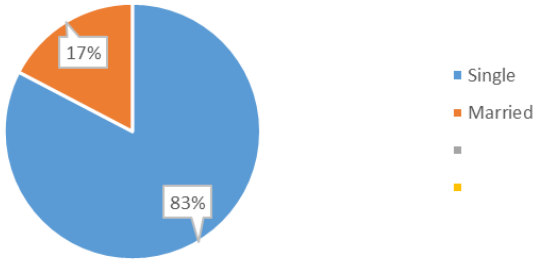

Figure 8. Frequency and Percentage distribution of the respondent according to civil status

Part II. Employment tracing of Home Economic 2018 graduates who did not proceed to college and TESDA Schools

The figure below shows the summary of the employment of 2018 Home Economic graduates who did not proceed to college and TESDA schools.

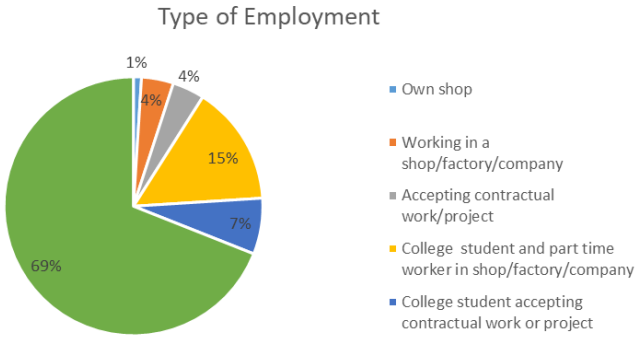

Figure 9, Frequency and Percentage distribution of respondents according to the type of employment utilizing their HE skills.

In Figure 10, it is illustrated that 52 individuals, representing 69 percent of the group, are earning an average monthly income between 1,000 and 5,000. Notably, this income is not directly related to the skills they acquired through their education; these individuals often have alternative sources of income or engage in different activities.

In contrast, 23 individuals, or 31 percent, are applying their skills in the workforce, earning a monthly income ranging from 6,000 to 10,000.

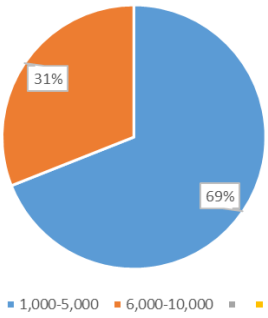

Figure 10. Frequency and Percentage distribution of the respondent according to their average monthly income

Figure 11 presents the frequency and percentage of Home Economics graduates from 2018 regarding their skill competency. Among them, 24 graduates (32%) hold an NC II certificate, while 6 graduates (8%) did not meet some competency requirements, receiving a Certificate of Completion (COC). Additionally, 14 graduates (19%) pursued a related course in college, and 1 graduate (1%) attended seminars, workshops, and training related to Home Economics. Notably, 30 graduates (40%) enrolled in college courses unrelated to Home Economics, and some respondents chose not to continue college at all.

According to Kiran S. Budhrani et al. (2017), the country continues to grapple with low educational attainment, high dropout rates, and unemployment, especially among the youth. Technical and Vocational Education and Training (TVET) plays a crucial role in postsecondary education by providing noncredit, technical training aimed at developing skilled workers. The Technical Education and Skills Development Authority (TESDA) leads the TVET system by implementing competency-based curriculum standards, training regulations, and assessment processes to ensure quality training across the nation.

As outlined in Sector 2 of the TESDA Act of 1994, TESDA's mandate is to deliver relevant, accessible, high-quality technical vocational education and skills training. This supports the development of skilled Filipino workers aligned with the country's development goals and priorities.

In conclusion, the findings indicate that those who are not competent in their skills tend to enroll in courses that do not align with their specialization from senior high school, representing the highest proportion of respondents. Furthermore, many studies tend to focus on professionalization in higher education, while some graduates have chosen not to pursue further college education after senior high school and have begun settling down instead.

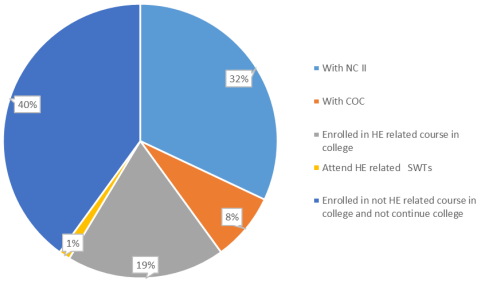

Figure 12. Frequency and Percentage distribution of the respondent according to their Home Economics skills development

According to the results, 43% are satisfied with their current income, while 32% are dissatisfied, and there are no respondents who rated their satisfaction as "very satisfied." This suggests that achieving satisfaction with income remains a challenge.

One of the main objectives of implementing an additional two years of senior high school is to better prepare graduates for college, future employment, or entrepreneurship (Asis, L.C. 2020).

Therefore, we conclude that those who have engaged in income-generating activities tend to be satisfied, which supports the objectives of the two-year senior high school program proposed by Asis (2020). However, some individuals feel dissatisfied due to their low income despite applying their technical-vocational skills. Additionally, while some are earning, they are not fully utilizing the TVL skills they have acquired.

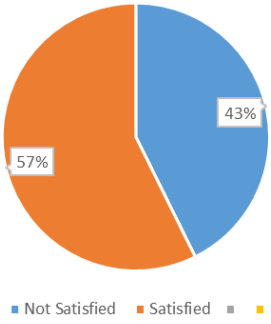

Figure 13. Frequency and Percentage distribution of the respondent according to satisfaction on their employment utilizing their HE skills

CONCLUSIONS

In the light of foregoing findings, the researchers arrived at the following conclusions:

1. Overall, there is a high percentage of K to 12 Batch 2018 graduates who do not have their shop and not working in the factory abroad compared to those who work in the company here in the country. Some are accepting contractual projects and are engaged in income-generating activity. There is a low employability of the TVL graduates of 2018. Therefore, the goal of the K- to 12 curricula was not met.

2. In conclusion, the findings indicate that individuals who failed to develop their skills typically took courses that did not relate to their specialization in senior high school. Additionally, some graduates chose not to attend college and have since settled into different careers.

3. We have found that people engaged in income-generating activities tend to support the two additional years of senior high school proposed by Asis (2020). However, some individuals are unhappy with their low income, as they feel they are not effectively using the technical-vocational (Tech-Voc) skills they acquired through the TVL program.

RECOMMENDATIONS

Senior High school students should join more seminars, workshops, and trainings.

1. After graduating from Senior High School graduates must obtain National Certificates. These NCs should be a requirement before enrolling in college courses aligned to the TVL track.

2. The government create a sustainability plan for those who do not pursue college, enabling them to apply and develop their skills for global competitiveness. This plan should also support college students in becoming productive citizens and "iskolar ng bayan."

3. Senior High School graduates must continue their education in college to enhance their skills and achieve mastery.

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EXPERIENCES AND CHALLENGES FACED BY IFUGAO STATE UNIVERSITY BACHELOR OF TECHNOLOGY AND LIVELIHOOD EDUCATION (BTLED) STUDENTS IN ONLINE AND TRADITIONAL LEARNING FROM 2018 TO 2022

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ABSTRACT

The study aims to determine the experiences and challenges met by the Bachelor of Technology and Livelihood Education (BTLED) students during online and traditional learning. Twenty-four Junior and Senior BTLED students enrolled in the 2nd semester of academic year 2021-2022 were the respondents of this study. Data were gathered through questionnaire and face to face interview. The data were analyzed using frequency count and percentage. Results showed that the majority of the students faced a lot of challenges in taking and submitting quizzes, activities and assessments. On the other hand, in the traditional way of learning, students experienced fewer challenges. In online learning student submitted their activities and quizzes late, due to poor connection, unclear instruction, limited time in answering the quizzes and activities. Moreover, the students did not have gadgets to be use. On the other hand, during the traditional learning, they submit their quizzes on time, access quizzes easily and have enough allotted time for answering quizzes, and submitting activities. The researchers find out that instructors assess learning by giving quizzes, examination, assignments and other activities by making extra effort to help students improve their grades, explain the relevance of the topic to the previous lessons and relate then to current issues that the students encounter in their daily life. The teachers also employ interactive discussions that encourage student's participation.

INTRODUCTION

Quality education provides the foundation for equity in society. Quality education enables people to develop all of their attributes and skills to achieve their potential as human beings and members of society. Quality education is one of the most basic public services. It enables students to develop all of their attributes and skills as human beings and members of society. Therefore, quality education implies looks into what desirable changes the educational institution wants to make in each student. Setting a high standard and help the student work toward them (Abdur Rashid,2019).

In addition, it identifies learners' cognitive development as the major explicit objective of all education systems and emphasizes education's role in promoting values and attitudes of responsible citizenship and in nurturing creative and emotional development. The challenge of improving quality of teaching by training teachers and supporting them with modern teaching aids, tools and methodologies like smart classrooms and digital course content--needs to be taken up so that teachers take pride in their classroom performances smoothly. The future of the country depends on a quality education being provided in every school and it plays a major role in the student education. Quality is at the heart of education. Alternatively, performance in licensure examinations is not the only measure of quality education. The quantity and quality of school inputs the effectiveness of the curriculum and teaching methods and the quality of the school and home environment (Abdur Rashid,2019).

The purpose of education has been and always will be to empower and impart skill and knowledge to leaners, thus it is important that the education one gets has to be of certain quality. Quality in education is important given the fact that what a person learns affects his/her philosophy "mind-set". Thus,

saying that the education one gets affects his/her day to day life depicting his/her lifestyle and the decisions he/she makes on a daily basis. Psychologically, learning is said to have occurred if there has been a change in behaviour of a subject, meaning that a person acclimatizes to what is being taught (Thangeda,Baratiseng&Mompati, 2016).

In the Philippine law, quality education for all citizens at all levels is the mandate of the constitution of the Republic of the Philippines. As stipulated in Article XIV, Section 1 of the 1987 constitution: "The state shall protect and promote the rights of all citizens to quality education at all levels and shall take appropriate steps to make such education accessible to all." Education is essential for everyone. Education helps people earn respect and recognition. It is indispensable in all aspect of life (personally, socially, physically, emotionally, spiritually and intellectually). However, the unequal standard of education is still a major problem that needs to be solved. Education plays a rudimentary role in our society that we cannot even imagine how life could be without it. It is a determined element for the civilization of human society. It does not only help us develop healthy surroundings, but it also generates an advance community. As a matter of fact, everything we create today is based on the knowledge that we obtain throughout our life by way of education.

Online and traditional education share many qualities. Students are still required to attend class, learn the material, submit assignments, and complete group projects. While teachers still have to design curriculums, maximize instructional quality, answer class questions, motivate students to learn, and grade assignments. Despite these basic similarities, there are many differences between the two modalities. Traditionally, classroom instruction is known to be teacher-centered and requires passive learning by the student, while online instruction is often student-centered and requires active learning.

Qureshi (2019) and Miles et al. (2018) contended that face to face is a teaching/learning method that enhances the teaching/learning process through interpersonal contact. These interactions can create a support network among students and teachers. Students may feel more comfortable and thus, learn easier in a familiar, traditional classroom setting. Moreover, this community and fraternity can sometimes increase their level of confidence, intelligence as well as alleviate problems often associated with learning in isolation. Thus face to face allows students to have greater scope of learning. Face to face is the more traditional type of learning instruction and it involves the transmission of information from the lecturer to the students (Bandara and Wijekularathna, 2017). It generally occurs in an enclosed physical classroom setting. Classes are conducted daily and may vary from early morning to afternoon and night. A whiteboard is normally placed to the front of the classroom, with furniture to accommodate both teachers and students.

Every country is presently implementing plans and procedures on how to contain the virus, and the infections are still continually rising. In the educational context, to sustain and provide quality education despite lockdown and community quarantine, the new normal should be taken into consideration in the planning and implementation of the "new normal educational policy". This article presents opportunities for responding issues, problems and trends that are currently arising and will arise in the future due to COVID-19 pandemic through the lens of education in the Philippines - the new educational norm(Tria Jose, 2020).

The unexpected outbreak of the Coronavirus (COVID-19) pandemic has affected almost every sector, including the higher education institutions around the world (Adedoyin & Soykan, 2020). To curb the spread COVID-19, most governments have opted to employ quarantine protocols and temporarily shut down their educational institutions. As a consequence, more than a billion learners have been affected worldwide. Among this number are over 28 million Filipino learners across academic levels that have to stay at home and comply with the Philippine governments quarantine measures (UNESCO, 2020). During this critical moment of the COVID-19 pandemic, most of the countries around the world shifted to online teaching (Bokayes et. Al, 2021).

Online learning can be termed as a tool that can make the teaching-learning process more student-centered, more innovative, and even more flexible. Online learning is defined as "learning experiences in synchronous or asynchronous environments using different devices (e.g., mobile phones, laptops, etc.) with internet access. In these environments, students can be anywhere (independent) to learn and interact with instructors and other students" (Singh & Thurman, 2019). The synchronous learning environment is structured in the sense that students attend live lectures, there are real-time interactions between educators and learners, and there is a possibility of instant feedback, whereas asynchronous learning environments are not properly structured. In such a learning environment, learning content is not available in the

form of live lectures or classes; it is available at different learning systems and forums. Instant feedback and immediate response are not possible under such an environment (Littlefield, 2018).

At-home learning has many benefits that are crucial to the health of students and family members. Online allows students to be engaged in school while not having to physically attend it, keeps students safe from coming in contact with COVID-19, and is cost effective. Students are able to participate in their regular classes through online school by using a variety of different methods such as Microsoft Teams, Google Classroom, Zoom, etc. This version of learning allows students to participate in school through synchronous and asynchronous lessons that teachers give through the school's preferred method of communication. Additionally, by using online learning students are socially distanced from others that could expose them to the coronavirus, so it has many health benefits for students and their loved ones. Lastly, e-learning is cost effective for schools because they don't have to spend as much on training or supplies. "Due to simplified logistics and lowered travel costs, among other factors, learning institutions who utilize e-Learning can expect to save 50% to 70% on overall training costs," says Sander Tamm from e-student.org. Through these several benefits to online learning, the method sounds extremely positive in its impacts and seems like the obvious choice for schools, but there are also countless negative impacts as well (Katherine Northenor, 2020). Among the main learning theories, the cognitivism and constructivism approach are deemed to apply best in the online classroom setting. The concept of cognitivism focuses on the stimulation of the student's learning strategies. It describes the idea that students process the information that they receive and reorganizes them to gain and store new knowledge. This is promoted through practical discussions and problem solving (Acevedo et al., 2020). According to the research of Mtebe & Raisamo, 2014. If the course is designed effectively then it will lead to higher acceptance of e-learning system by the students and their performance also increases.

The negative effects of online course-taking are particularly pronounced for less-academically prepared students and for students pursuing bachelor's degrees. New evidence from 2020 also suggests that the switch to online course-taking in the pandemic led to declines in course completion. However, a few new studies point to some positive effects of online learning, too. This post discusses this new evidence and its implications for the upcoming academic year (Cellini (2021).

The level of academic performance of the students is likely to drop for the classes held for both year-end examination and internal examination due to reduced contact hour for learners and lack of consultation with teachers when facing difficulties in learning/understanding (Sintema, 2020). The production quality and the delivery of the content by the instructor are crucial for engaging the students. Poor audio and visual quality will ultimately decrease attention and understanding among learners (Molnar, 2017). If there's one thing college students nationwide can agree on, it's that Zoom classes suck. Necessary as it may be in the age of COVID-19, staring at your screen for nine hours a day while your professor tries to explain the difference between judicial activism and judicial restraint is draining to say the least. Having exclusively online interactions can have a real impact on the mental health of both students and professors. "Zoom fatigue" is real – video chats make it harder for our brains to process "non-verbal cues like facial expressions, the tone and pitch of the voice, and body language," (Ana Pietrewicz, Assistant, 2020).

STATEMENT OF THE PROBLEM

The research aimed to assess the Challenges face by the K-12 graduates who enrolled in the BTLED Program from 2018-2021 vis-à-vis online mode of learning and of that traditional learning.

Specifically, it sought to answer the following questions:

1. What are the respondent's perception about online learning and traditional learning in terms of:
   1.1 taking quizzes,
   1.2 submission of learning activities, and;
   1.3 midterm and final examination?
2. What are the respondents perception on their teachers' teaching methodology during the online and traditional learning?
3. What are the challenges encountered by the respondents during the taking quizzes, submission of learning activities and taking midterm and final examination s in online and traditional learning?
4. How did the respondents manage the identified challenges in online and traditional learning?

5. What are the respondents recommendation /suggestions to improve that delivery of instruction in online and traditional learning?

METHODOLOGY

Research Method

In this study, the researchers used quantitative research which determined the extent of a relationship between face-to-face learning and online learning to the academic performance of the students.

Research Environment

This research was conducted at Ifugao State University Lagawe Campus located at Bahawit, Poblacion West, Lagawe, Ifugao, 3600Philippines.

Research Instrument

The main instrument used in gathering the data was a survey questionnaire adopted from the study of Potang M. et al. 2022, specifically on the teaching methodology. The rest were formulated by the researchers.

Respondent

The respondents of this study were the K to 12 graduates admitted in the BTLED program from 2018-2021 in the College of Education. All the 3rd and 4th year BTLEd students were taken as respondents with a total of 13and 11 respectively.

Data Gathering Procedure

In gathering the data, the researchers gave a request letter to the Campus Executive Director for permission to conduct the research study. The researchers carefully prepared and modified the questionnaires, where the respondents provided the needed data.

The researchers administered the questionnaires to the respondents on site and online. After the retrieval of the questionnaire, the researchers transcribed the result of the questionnaire and analyzed the data.

Campus is located in Barangay Poblacion West, one of the 20 barangays of the Municipality of Lagawe, Ifugao. Officially the Municipality of Lagawe is a 4th class municipality and capital of the province of Ifugao, Philippines. According to the 2020 census, it has a population of 18,876 people.

FINDINGS

The chapter presents the findings of the study as organized and presented in chronological order following the sequence of the statement of the problem.

1. Perception of Respondents on Online and Traditional Learning.

Frequency and percentage distribution of the respondents on their perception in Online and Traditional learning in terms of taking quizzes shows that the students during online learning cannot passed their quizzes on time, they have not enough time to read the question before answering it, and most of all they are not prepare to take the quizzes online due to the poor connection or access or good internet connection.

Frequency and percentage distribution of the respondents on their perception in Online and Traditional Learning in terms of submitting learning activities show that the students did not submit their activity easily and they have problem in comprehending the instructions on how to accomplish and submit the activity during online while they did not encounter such problem during traditional learning. Supported by the study of Maraseni et al., that late submissions of assignment is an indication of poor quality in terms of student's performance, therefore, students' request for an extension on their assignment due to date is more probably, attributed to their poor time management rather than desire to improve performance.

Table 1. Frequency and percentage distribution of the respondents on their perception in Online and Traditional Learning in terms of midterm and final examination.

Assessment (Midterm/final examination) Online learning and Traditional Learning	Online Learning				Traditional Learning			
	Yes	Percentage %	No	Percentage %	Yes	Percentage %	No	Percentage %
Q1. Do you have good access of the internet connection?	6	25%	9	37.5%	11	45.8%	3	12.5%
Q2. Do you access your test paper easily?	7	29.9%	7	29.9%	14	58.3%	1	4.1%
Q3. Do you submit all your midterm and final examination?	12	50%	6	25%	14	58.3%	3	12.5%
Q4. Do you provided enough time in answering your examination?	18	75%	0	0	17	70%	0	0
Q5. Does your instructor check quizzes and examinations and gives feedback to students?	9	37.5%	9	37.5%	13	54.1%	0	0
Q6. Does the instructor follow the schedule given by the registrar?	7	29.1%	11	45.8%	16	66.6%	1	4.1%
Q7. Are the entire questions in the examination discussed by the instructor?	15	62.5%	3	12.5%	17	70%	0	0
Q8. Do the teachers use technique to ensure that students are honest and not cheat in their quizzes, examinations, etc. ex. Time limit, videos of students taking the exam?	15	62.5%	3	12.5%	15	62.5%	0	0

The table revealed that 37.5 % of the students on online learning have poor internet connection and 45.8% of the students claims that instructors does not follow the schedule given by the registrar. Moreover, 62.5 % of the students on online learning claims that most of the questions in the examinations had been discussed by the instructors. Furthermore, 75%claims that instructors give enough time in answering the examinations.

Meanwhile, during the traditional learning, students provided enough time to answers the examination while following the schedules given and submit it on time. Also, the student claims that instructors give feedback about the examinations results. Both instructors in online and traditional learning used technique to ensure that students do not cheat and practice honesty in their examinations.

However, there were few students who experienced technical or practical problems in completing their exam remotely. Test anxieties were reduced for some students but increased for others. The majority of students preferred the traditional setting of invigilated exams in computer lab, feeling this ensured an even playing field for all candidates, Alan Jaap et al.,2021

2. Perception of Students on their Teachers' Teaching Methodology during Online and Traditional Learning.

Table 2. Frequency and percentage distribution of the respondents on their perception in Online and Traditional learning in terms of teaching method.

Teaching method (Online learning and Traditional Learning)	Online Learning				Traditional Learning			
	Yes	Percentage%	No	Percentage%	Yes	Percentage%	No	Percentage%
Q1. Instructor makes extra effort to help students improve their grades and succeed.	15	62.5%	3	12.5%	17	70%	0	0
Q2. Instructor explains the grading system or method of giving grades.	16	66.6%	1	4.1%	16	66.6 %	1	4.1%
Q3. Does the Instructor assess learning by giving quizzes, examinations, assignments and other activities?	18	75%	0	0	17	70%	0	0
Q4. Are instructions clear, realistic and attainable as presented in the learning packages/IMs?	10	41.6%	2	8.3%	15	62.5 %	2	8.3%
Q5. Does the Instructor communicate or follow-up if student have printed or e-copies of their IMs/ learning packages/manuals, etc?	14	58.3%	3	12.5%	16	66.6 %	1	4.1%
Q6. Does the Instructor master, prepare very well lessons?	17	70%	2	8.3%	17	70%	2	8.3%
Q7. Does the Instructor explain the relevance of present topic to the previous lessons and relate in the subject matter to relevant current issues and/or daily activities?	18	75%	0	0	17	70%	0	0
Q8. Does the instructor conduct classes following schedules with any changes being communicated in advance to students via announcements or other forms?	11	45.8%	6	25%	15	62.5 %	2	8.3
Q9. Does the instructor employ interactive discussion and encourage student participation?	18	75%	0	0	16	66.6	1	4.1

The figure show that most of the teaching methods in online and traditional learning were executed properly like making extra effort to help students improve their grades and succeed, explaining grading system, rubrics or method of giving grades, employing interactive discussion and encouraging students' participation and etc. The figure shows that teachers' teaching method during online and traditional learning have significant differences. In online learning, 62.5% of instructor makes extra effort to help students improve their grade and succeed, 66.6% of instructor explains the grading system or method of giving grades, 75% assesses learning by giving quizzes, examinations, assignments and other activities.

Moreover, 70% of the instructor master, prepare very well and clearly explain the lesson. Furthermore, the table shows that 75% of instructor explain the relevance of present topic to previous lessons and employ interactive discussion and encourage student participation.

On the other hand, in the traditional learning, the table shows that 70% of instructor makes extra effort to help students improve their grade and succeed, assesses learning by giving quizzes, examinations, assignments and other activities, masters, prepares very well and explains lesson clearly, explains the relevance of present topic to the previous lessons and relates subject matter to relevant current issues and daily activities.

Moreover,66.6% of the instructor explains the grading system or method of giving grades, communicates or follow-up if student have printed or e-copies of their IMs/ learning packages/ manuals, and employs interactive discussion and encourages student participation.

Nahid et al, 2016 claimed that good teaching method helps the students to question their preconceptions, and motivates them to learn, by putting them in a situation in which they come to see themselves as the authors of answer, as the agents of responsibility for change.

3. Challenges encountered by the respondent during the taking of quizzes, submitting learning activities and taking examinations in online and traditional learning.

On Online quizzes, examination and submission of activities, it is evident that students face a lot of challenges namely poor internet connection, insufficient time to prepare, answer and submit activities on time, unclear instruction to the activities, teacher do not follow the schedule given by the registrar, and some students do not have gadget, to be used in online class. On the other hand, during the interview, majority of the students stated that they don't have a lot of problem during the traditional learning or No comment.

(Ordinario, 2017 & PIDS, 2017) studies support the finding that poor internet connectivity is also a major challenge in the student's online distance learning. In addition, many countries particularly the schools in North Macedonia were closed during the pandemic and learning is taking place online. The amount of content, online assessment, and inadequate instructions, is just some of the problems that young people face in this new learning environment. The truth is, for many students, online learning is only a formality and not a real substitute for regular teaching. Some teachers only share learning material to students without teaching it. Online testing is sometimes based on the principle of "work it out yourself". Students are not acquiring real, long-lasting knowledge. Some students are not even properly equipped to attend online classes. They don't have electronic devices such as computers, telephones and cameras. The number of these devices in households is often limited which can be very inconvenient for online appointments, classes, and meetings that take place simultaneously. Also, some teachers don't consider the fact that during online testing, the student may lose the internet connection. Unfortunately, if this happens, the student gets graded based on the number of questions answered and recorded in the system before the connection was lost. Students also face problems managing their own time as a result of online teaching (Milosievski, 2020). Time management is one of the life skills students are expected to acquire during their time at university and dealing with workload is an issue for both academics and students. It is suspected that students do not initially manage their time very well and use deadlines to control when and what they do. However, it is also believed that students' time management improves as they progress through their course (Gregory et.al).

4. Managing Identified Challenges in Online and Traditional Learning.

With those problems and challenges that students identified during their online learning, they managed it through explaining their situation to the instructor and ask for consideration. Some students even pleaded to reschedule the quiz, and the submission of activities. While on the other hands in traditional learning student don't face any sort of problems.

CONCLUSIONS

1. In online learning, students submit their activities, quizzes and examinations late due to poor connection, unclear instruction, limited time in answering the quizzes and activities and don't have gadgets to use. On the other hand, during the traditional learning, they submit their quizzes on time, access the quizzes easily and have enough allotted time for answering quizzes, and submitting activities. There's no need to worry about the internet connection because of the location of the school. With regards to gadgets, the IFSU has internet room for the students to use in surfing, encoding and other ICT purpose.
2. Instructors assess learning by giving quizzes, examination, assignments and other activities, by making extra effort to help students improves their grades, explaining the relevance of the topic to the previous lessons, relating to current issues and daily life and employing interactive discussion that encourage student's participation.
3. Firstly, most of the respondents faced poor internet connection. Secondly, respondents experienced difficulty in understanding the instruction given by their instructor. Thirdly, respondents complain about limited time to review, take quizzes and do activities. Lastly, the instructors are not following the schedule given by the registrar during online learning. On the other hand, majority of the respondents have no complaints on traditional learning in term of taking quizzes, submitting activities and taking assessments (midterm and final).
4. With the above-mentioned challenges, the respondents cope by: First, explaining their situation to the instructors and asking for consideration; Second, applying time management; Third, asking instructor for their clarification to the given instruction; and Fourth, pleading to re-schedule the quizzes and activities.
5. Through their experiences on online and traditional learning the respondents come up to the following suggestions:
   a. Instructors must consider those who have unstable internet connection.
   b. Instructors must give instruction clearly.
   c. Instructors should give time to finish the activity considering the internet connection.
   d. Instructors must give feedback regarding submitted activities for improvement.

RECOMMENDATIONS

1. Students immediately informed their instructors about the internet connections in their places, ask for considerations and suggest the most applicable way to pass the activities and quizzes and take examination.
2. Maintain the good practice of teacher teaching method to aim the IFSU goals-academic excellence.
3. Instructors must give clear instruction about the activity and quizzes. Use specific social media platform that is accessible for all students. Also, Instructors should give consideration to those who have unstable internet connection or apply other teaching strategies that don't need internet connection. On the other hand, students do some effort to pass their quizzes, activity and examination on time.
4. Students attend seminar workshop regarding time management and effective study habit and teachers should consider the reasons behind students' shortcomings.
5. To address challenges brought by unstable signal, unclear instructions, limited time, and assessment feedback experienced by learners, Instructors should give consideration to those who have unstable signal, must make the instruction in every activity and quiz clear, generously give feedback regarding the submitted activity for improvement, expound lessons through giving real life explanation and follow schedules to avoid conflict with other subject.
6. Future researchers may conduct the same study in other programs in higher education to validate the study. It is also recommended the inclusion of faculty as respondent and the level of student satisfaction on the online learning and traditional learning is considered.

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THE FEASIBILITY OF EGG STRINGS WEDGE SEA HARE (*Dolabella auricularia*) AS A NON SELECTIVE CULTURE MEDIUM

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ABSTRACT

This study is conducted to develop a culture media derived from a marine product using egg strings (*lukot*) of *Dolabella auricularia* as the primary source for bacterial growth, the study follows an experimental research design, evaluating colonial growth based on Absolute Growth Index (AGI) and Centers for Disease Control and Prevention (CDC) classified colony morphologies. A 40% egg string stock solution is made by mixing 60 ml of shredded egg strings and 90 ml of distilled water, divided into 25 ml, 50 ml, and 75 ml. These extracts are combined separately with 6g bacteriological grade agar, varying amounts of distilled water to reach a total volume of 250 ml egg string agar (ESA) solution. Nutrient agar (NA) act as the positive control. Using four-quadrant streaking technique, culture plates are incubated at 37°C for 24-48 hours. *Escherichia coli* and *Staphylococcus aureus* assess ESA's viability compared to NA. The AGI scores and mean ranks are analyzed using the Kruskal-Wallis Test. Results show ESA supports the growth of both *E. coli* and *S. aureus*, with *E. coli* forming more colonies than *S. aureus*. Pinpoint, mucoid, white, translucent, and punctiform colonies with entire margins have been noted for *E. coli* growth, while *S. aureus* appeared pale yellow, opaque colonies. Statistics reveal that no significant difference in the mean ranks of AGI for *E. coli* growth between ESA and NA but a difference for *S. aureus S. aureus*, The integration of egg strings of *Dolabella auricularia* has promising potential for bacterial cultivation, with opportunities for optimization considerable research .

Keywords: Bacteriology, medical technology, alternative culture medium, Dolabella auricularia, egg strings, bacterial growth, experimental, microbiology-parasitology laboratory

INTRODUCTION

The world's oceans are extraordinarily abundant in seafood, encompassing a diverse and vast array of marine life. Known as "donsol" in the Cebuano dialect, the wedge sea hare, or *Dolabella auricularia*, is a species of Opisthobranch mollusk belonging to the Aplyssidae family. It is found remarkably abundant in shallow tropical shorelines and is known to feed on algae or seagrasses (Ruaza, 2023). The organism lays its egg in a gelatinous string-like mass that is typically attached to eelgrass or seaweed. The spawning and recruitment period of the wedge sea hare occurs throughout the year, with peaks in May and July, as well as September to October (Nur, 2023). The egg strings of the wedge sea hare *Dolabella auricularia* consist of 91.10 moisture, 0.85 total fat, 2.85 protein, 3.43 ash, and 1.77 carbohydrates based on percent composition (Pepito et al., 2015). These egg strings present a compelling way to obtain sustainable and nutritious food sources, contributing to the exploration of alternative, eco-friendly options for human dietary needs. Moreover, the egg strings of wedge sea hare *Dolabella auricularia* reveal culture-yielding ability, showcasing promising nutrient content and gel-forming characteristics.

Culture media provides nutrients for bacterial growth in a laboratory setting. However, for some, the excessive cost of traditional culture media poses problems, especially for developing nations (Adesemoye & Adedire, 2005). Although there is a continuous development in the use of alternative media, the majority of these innovations are centered around the utilization of agricultural wastes. With this, the researchers have identified the need to explore other origins, particularly seafood. Hence, this study focused on investigating the egg strings of the wedge sea hare, *Dolabella auricularia*, as a potential nutrient-rich source for culture media. It has never been clearer that looking into other choices for culture production is crucial for sustainable and cost-effective practices in health and medicine. Culture media can be classified as liquid, semi-solid, and solid media on the basis of consistency and concentration of the agar (Meszaros, 2022). The expense and scarcity of culture media impede practical microbiology classes and scientific research in developing countries, especially in financially constrained institutions (Santos et al., 2021). Therefore, it is of the essence to address this dilemma and generate a culture medium that is both scientifically and economically sound. The traditional culture media are applied extensively in the laboratory today. Ultimately, different aspects will continue to affect the reasons for seeking alternatives. Nonetheless, it all boils down to wanting to better understand the bacteria, their characteristics, behavior, and propensity to cause diseases.

This study is anchored on the Pure Culture concept developed by Robert Koch in 1881, which is further supported by William Burrows' Nutritional Requirements of Bacteria (1936) and the Econometric Method gauged by Mossel et al. (1980). For Robert Koch (1881), pure culture is the foundation of all research on infectious diseases. Ironically, it was Joseph Lister who first obtained pure culture in a liquid medium using a limiting dilution method (Lister, 1878). The complexity surrounding the mechanisms of growth and isolation of bacteria is undeniable. Balanced growth is a steady state condition where cells attain the maximum growth rate possible for a particular medium. This case implies that the time it takes to double the cell number will be the same time it takes for these cells to double their content of DNA, ribosomes, individual enzymes, and the rest of the system (Shand et al., 1999).

STATEMENT OF THE OBJECTIVES

This study determined the potential of the egg strings [lukot] of *Dolabella auricularia* to act as the primary source of nutrients with the bacteriological grade agar as a solidifying agent in developing an alternative culture medium.

Specifically, this study aimed to meet the following:

1. To determine the potential of the egg strings as a nutrient source for bacterial growth by preparing a 40% egg strings extract solution from which three distinct and increasing volumes will be derived
   1.1. Setup 1: 25 mL string egg strings extract [4.4%] in 6g of agar and 225 mL distilled water;
   1.2. Setup 2: 50 mL string egg strings extract [10%] in 6g of agar and 200 mL distilled water; and
   1.3. Setup 3: 75 mL string egg strings extract [17.14%] in 6g of agar and 175 mL distilled water.
2. To demonstrate the ability of the test media to promote the survival and multiplication of bacteria by using *Escherichia coli* and *Staphylococcus aureus* as test microorganisms.
3. To describe the morphology of bacterial colonies in both NA and ESA through characteristic description [size, surface appearance, color, shape, and microscopic density] established by the Centers for Disease Control and Prevention [CDC].
4. To indicate the presence of bacteria in all culture plates by conducting confirmatory tests
   4.1. Catalase and Coagulase Tests for *Staphylococcus aureus*; and
   4.2. IMViC Test for *Escherichia coli*.
5. To evaluate the performance of Egg String Agar [ESA] against Nutrient Agar [NA] through comparison of the absolute growth index of the test microorganisms inoculated in both media.

Statement of Hypothesis

There is no significant difference between the newly formulated Egg String Agar [ESA] and Nutrient Agar [NA] in terms of Absolute Growth Index, biochemical test results, and colonial characteristic evaluation

METHODOLOGY

Research Design

This study utilized an experimental method grounded on the study conducted by Deslate et.al on the formation of an alternative culture media through organic ingredients that enabled growth of medically important bacteria such as *Staphylococcus aureus* and *Escherichia coli*. This allowed a systematic and scientific approach in determining the potential of the egg strings [lukot] of *Dolabella auricularia* with bacteriological grade agar powder as its solidifying agent as a nutrient source for bacterial growth. An experimental research design enables researchers to precisely conduct processes and conclusions, permitting an organized and objective-focused study.

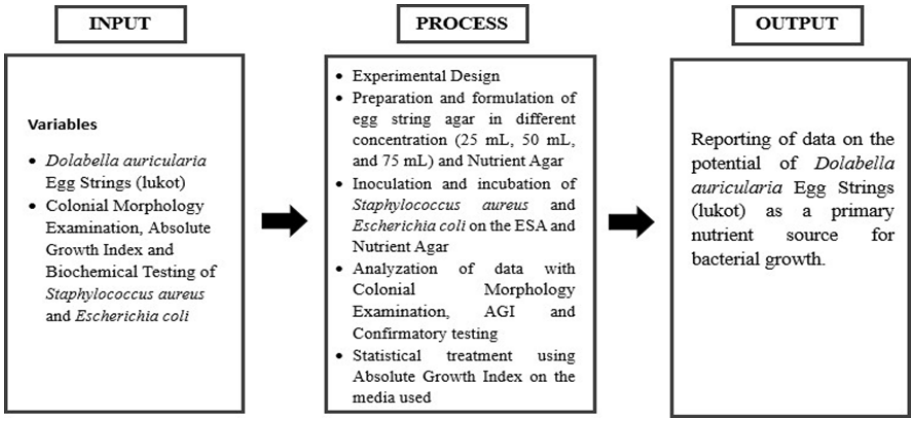


Figure 1. Research Flow Process

Research Environment

The egg strings [lukot] of Dolabella auricularia were gathered by a local fisherman in Sulangan, Bantayan, Cebu. He was recommended by the seafood vendor from the Bantayan Public Market that was approached and consulted during the pre-procurement stage. A representative from the group was in constant communication with both individuals to guarantee the availability of the egg strings and oversee their proper harvesting so as not to resort to hoarding. They were then packaged securely in an ice-filled container and were fetched at the Cebu North Bus Terminal. The fisherman and seafood vendor involved were duly compensated by the researchers. Simultaneously, the bacteria [Staphylococcus aureus and Escherichia coli] were processed and received from the Microbiology laboratory of the University of Cebu Medical Center. Upon assembling all the samples, the researchers returned to the University of Cebu - Banilad Campus to finally conduct the study. From running the test procedures to data analysis, the researchers worked within the premises of the said university, particularly in the Microbiology-Parasitology laboratory of the Medical Technology department. The objects and instruments essential for carrying out the experiment were gathered at this location. (See Appendix D- Location Map)

Research Subject

Human participation was not a component of this research. The study exclusively focused on creating a substitute to the cultivation media conventionally used in the laboratory. For this reason, Escherichia coli and Staphylococcus aureus served as key contributors to analyze the viability of the product. These bacterial strains were inoculated into the growth media— Nutrient Agar and ESA. The commercially available Nutrient Agar was used as a positive control. It is a general-purpose medium made up of peptone, beef extract, yeast extract, and agar. These ingredients provide the carbon, vitamins, trace elements, and nitrogen necessary to have the best conditions for the proliferation of bacteria (Sandle, 2019). For the purpose of formulating a new media, the egg strings of Dolabella auricularia were utilized as a source of nutrients for the growth of bacteria. They are excretions arising from the marine algae consumed by the wedge sea hare. Seaweeds and algae are known to be naturally rich in nutrients which makes the egg strings passed from the said marine invertebrate abundant in organic matter. Hence in this context, the vital carbon and energy that bacteria required to flourish came from the egg strings. The two

media inoculated with the bacteria were observed, and the colonial growth was compared. All laboratory procedures adhered to standard protocols to ensure proper handling of the bacteria, and the egg strings underwent meticulous treatment to prevent any contamination.

Sampling Technique

Purposive sampling technique was implemented through which the researchers had chosen the samples. Egg strings were selected for inclusion due to its nutritional composition having the potential to provide the primary growth requirements of the bacteria and mineral content close to that of the Nutrient Agar. On the other hand, *Escherichia coli* and *Staphylococcus aureus* were the bacterial species preferred to test and evaluate the newly formulated alternative culture media. Not only are they clinically relevant, but they also have distinct growth characteristics and are two of the most well-known and studied bacteria in the field of microbiology, making them reliable models for the experiment.

Inclusion and Exclusion Criteria

The egg strings of *Dolabella auricularia* had to meet the specific criteria to be included in the study. Egg strings found to be in fresh state, good condition, and healthy based on their appearance and size were chosen. In addition, only *Escherichia coli* ATCC 25922 and *Staphylococcus aureus* ATCC 29213 were obtained to be part of the experiment. The said bacteria were subcultured first prior to inoculation on both test [ESA] and control [NA] media. These indicators were set to fulfill the study objectives and ensure standard protocols were followed to avoid compromising research outcomes.

In establishing the exclusion criteria, several considerations were given to the research subjects concerned. Dried out, foul-smelling, crushed or damaged egg strings with visible signs of fungal or bacterial contamination were excluded. Specific color of the egg strings didn't matter as long as it was not unusual. For the test microorganisms, strains that are not of S. aureus and E. coli were left out. The proponents specifically sought these bacteria in pure cultures to secure proper identification, contamination prevention, specificity, and reproducibility during testing. The bacterial strains were dispatched from the source laboratory following standard operating procedures which included preparing a container filled with ice to preserve the organisms during transport to the college laboratory.

Research Instrument

This section presented the data collection tools that were fused into the study for a systematized gathering of information. The colony morphologies were reported in a manner described by the Centers for Disease Control and Prevention [CDC]. Visual culture characteristics comprise the size, surface appearance, shape, margin, and density of a bacterial colony on an agar plate. A validation form corresponding to the said parameters was given to the consulting medical technologist whose technical skills and expertise in microbial identification were the most qualified for evaluating and certifying experimental results. (See Appendix E- Validation Tool). A tabular report detailing the results of the confirmatory testing was also arranged to fit the description conceived from morphological examination, further confirming the identity of the bacteria present. The Microbiology-Parasitology laboratory provided the rest of the apparatuses and machines indispensable for the experiment to be possibly done.

Research Procedures

Data Collection

The researchers sought approval from the College of Medical Technology of the University of Cebu -Banilad, the University of Cebu Academic Research Ethics Committee [UCAREC], and a Microbiology and Water Testing Cluster Supervisor from the Vicente Sotto Memorial Medical Center to ensure transparency, accountability, scientific integrity, and ethical compliance. Fresh two [2] kilograms of egg strings of *Dolabella auricularia*, was acquired from the coastal waters of Sulangan, Bantayan, Cebu. Additional materials were purchased from Cebu Far Eastern Drug, Inc., and Southern Pharmacy in Cebu City. Prior to experimentation, the samples were authenticated by the Bureau of Fisheries and Aquatic Resources for and identified by a food technologist and the samples were immediately processed upon arrival. Following the steps by Tayone et al. (2021) with a few modifications, the samples were washed with sterile filtered seawater, tap water, distilled water, then drained and stored in a covered plastic basin. The egg strings were crushed using an electric blender to increase surface area and enhance solubility. The extract was filtered twice through muslin cloth, and a 40% v/v stock solution was prepared by

mixing 60 mL filtrate and 90 mL distilled water. This solution was divided into three Erlenmeyer flasks (25 mL, 50 mL, and 75 mL) and refrigerated at 4°C for 24 hours.

Extracts of the egg strings, distilled water, and solidifying agent were gathered to be the ingredients of the media. The solidifying agent that the researchers utilized was a bacteriological grade agar powder. Table 1 presents the different egg strings agar [ESA] formulations that served as the test media for the experiment. For the agar powder, the quantity had been standardized at 6 g and every setup had a distinct volume of the 40% egg strings extract as stated earlier in the objectives- 25 mL, 50 mL, 75 mL. Distilled water was added to each group such that the total volume of the individual mixture was equivalent to 250 mL. When the measurements were finally done, the corresponding amounts of both the distilled water and agar powder were poured and mixed carefully in three [3] separate Erlenmeyer flasks. The 25 mL, 50 mL, and 75 mL egg strings extracts that were once stored in the refrigerator were taken out and thawed at room temperature. The mixtures were heated with constant stirring, sterilized by autoclaving at 121°C for 15-20 minutes, and dispensed into sterile petri dishes. The plated media were allowed to solidify completely at room temperature all while inspecting the color and appearance of each culture medium.

Table 1. Formulation of Egg Strings Agar

Components	Setup 1	Setup 2	Setup 3
Egg Strings Extract	25 mL	50 mL	75 mL
Distilled Water	225 mL	200 mL	175 mL
Agar –Agar Powder	6 g	6 g	6 g

Pure cultures of *Staphylococcus aureus* (Gram-positive) and *Escherichia coli* (Gram-negative) were obtained from the University of Cebu Medical Center. A sub culture of Staphylococcus aureus bacteria was prepared by taking a loopful of the said bacteria from the pure culture provided and was inoculated into the Nutrient Agar plated media using the streak plate method to attain individual bacterial colonies. The same methods were applied for *Escherichia coli*. The plates were incubated for 48 hours at 37 °C and were then transferred to the laboratory refrigerator to preserve the bacterial growths until they were used for the microbial inoculation of the Egg String Agar media. The four-quadrant streaking method was used to inoculate ESAs and Nutrient Agar with individual bacterial colonies. Plates were incubated at 37°C for 24-48 hours and observed for morphology in triplicates. Colonies observed were subjected to a series of confirmatory tests to check for their purity and ensure that samples were not contaminated. To attest the presence of S. aureus, Catalase and Coagulase Tests were done. A group of biochemical tests, recognized as IMViC [Indole, Methyl Red, Voges Proskauer and Citrate] were performed to probe for E. coli. The researchers approached the Biology Department of the University of San Carlos-Talamban for assistance as resources substantial to perform these tests were scarce at the Microbiology-Parasitology laboratory of the University of Cebu-Banilad.

Quality control measures were put in place to meet consistent, reliable, and reproducible results. Part of this was obtaining the samples and materials from reputable suppliers. Procedures followed the guidelines of the American Society of Microbiology (ASM) and the Clinical and Laboratory Standards Institute (CLSI) M22 standard to ensure sterility, safety, precision, and accuracy. The detailed instructions and protocols in these two resources gave researchers a model to observe and maintain the level of sterility, safety, purity, precision, and accuracy expected from a practice of science.

Treatment of Data

Results were analyzed by Kruskal-Wallis H Test. The level of statistical significance was set at $p<0.05$. Through this statistical test, the mean rank of the Absolute Growth Index, the dependent variable, of both E. coli and S. aureus among different volumes of egg strings extract [25 mL, 50 mL, and 75 mL], the independent variable, was compared. This guided the researchers in interpreting results and understanding the relationship between the sets of data.

FINDINGS

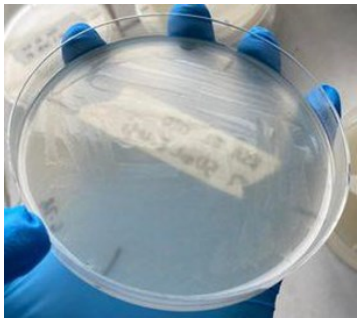
The performance of ESA in contrast with NA to propel bacterial growth for scientific and clinical applications is compared in this chapter. The data in this study were obtained directly from the practical investigation done by the researchers. A registered medical technologist with expertise in bacteriology evaluated the culture plates and gave a rating, further validating the test results. The data is presented in comprehensive tables and images that illustrate the growth patterns noted in both the alternative and control media. Following that, the data sets are analyzed with the help of established benchmarks to elucidate significant differences and trends. Finally, the interpretation dives into the implications of the findings, discussing the relationship between emerging factors and accentuating the impact of the research outcomes on microbial cultivation practices.

Part I. Evaluation of the Performance of Egg Strings Agar and Nutrient Agar

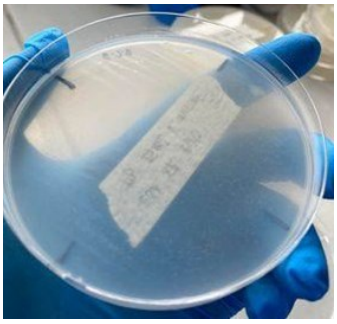
A. Bacterial Growth

As repeatedly emphasized in the preceding chapter, a culture medium could spur the growth of microorganisms and could be evaluated through its ability to display colonies on its surface. With that in mind, below were the results gained after putting egg strings extracts together with bacteriological grade agar and distilled water to become ESA for the cultivation of bacteria. These data were recorded to answer the questions surrounding the first two objectives of the study, which in particular were investigating the potential of the 40% egg string extract in three distinct volumes to sustain the recovery of the test microorganisms – Escherichia coli and Staphylococcus aureus.

Table 2. Bacterial Growth Across Different Volumes and Replicates



Escherichia coli



Staphylococcus aureus

Volume	Replicate 1	Replicate 2	Replicate 3	Replicate 1	Replicate 2	Replicate 3
25 mL	+	+	+	+	+	-
50 mL	+	+	+	+	+	+
75 mL	+	+	+	+	+	-

Table 2 shows comparison of the growth of both bacteria – E.coli and S. aureus in different volumes [25 mL, 50 mL, and 75 mL] across three [3] replicates. The "+" sign indicates growth, while the "-" sign indicates no growth. For *Escherichia coli*, consistent growth was observed across all volumes in triplicates, indicating that *E. coli* was able to thrive in the Egg String Agar [ESA] regardless of the volume of the extract mixed into the media. In contrast, *Staphylococcus aureus* exhibited a variable growth. At 25 mL and 75 mL, growth was only observed in Replicates 1 and 2, leaving Replicate 3 with no growth. Interestingly, the addition of the 50 mL volume of the egg strings extract led to the growth of S. aureus in all replicates.

At the time of observation, the researchers examined the ESA plates firstly via the presence or absence of colonies. Despite noting colonies on ESA plates inoculated with S. aureus, the growth of E. coli was more noticeable and easier to distinguish than the former. Colonies of *E. coli* were also more abundant compared to the colonies of S. aureus. This may be due to S. aureus having less reproductive ability than *E. coli*, as Nurmalasari et al. (2022) reported in their study about using almonds for alternative culture media. They even supplemented that E. coli have the power to double their bodies within 15-20

minutes, while S. aureus bacteria usually reaches 25-28 minutes of division time on a simple medium, thereby suggesting that the growth of Escherichia coli bacteria is faster than Staphylococcus aureus.

Besides that, the limited growth displayed by S. aureus in contrast to *E. coli* can be attributed to the differences in structure and composition of the cell walls of Gram-positive and Gram-negative bacteria, as well as presence of inhibitory compounds. Flavonoids are secondary metabolites that include flavones, flavanols, and tannins. Sea hare organisms obtain these compounds from the algae they eat. Gram -negative bacteria like *E. coli* are able to grow and are more resistant to the activity of polyphenols than Gram-positive bacteria because they have a periplasmic space which the latter lacks. In the case of Gram -positive bacteria such as S. aureus, their cytosol is wrapped with one bilayer membrane attached to a thick layer of peptidoglycans. However, as polyphenols also exhibit hydrophobic character, it can readily disturb the stability of Gram-positive cells. This disruption occurs because phenolic acids are capable of causing irreversible changes in cell membrane structures and interfering with their hydrophobic properties (Yu et al., 2011).

B. Colony Morphology

The following tables of Colony Morphology of the Bacteria tested illustrates the third objective of our study: to describe the morphology of bacterial colonies in both Nutrient Agar (NA) and Egg String Agar (ESA) through characteristic descriptions established by the Centers for Disease Control and Prevention (CDC). These characteristics include size, surface appearance, color, shape, and microscopic density. By comparing the morphological features of colonies grown on NA and ESA, we aim to determine whether ESA can serve as a viable alternative medium for bacterial growth. The results from these observations directly address the research problem by evaluating the efficacy of ESA in comparison to NA.

Table 3. Colony Morphology of Escherichia coli in Nutrient Agar and Egg String Agar

	Egg String Agar			Nutrient Agar		
	Morphology	**Frequency**	**Percentage**	**Morphology**	**Frequency**	**Percentage**
Size	pinpoint	7	100%	small	1	100%
Surface Appearance	mucoid	7	100%	mucoid	1	100%
Color	white	7	100%	pale yellow	1	100%
Density	translucent	7	100%	opaque	1	100%
Form	punctiform	7	100%	circular	1	100%
Margin	entire	7	100%	entire	1	100%

Table 3 presents the frequency distribution of the colony morphology of Escherichia coli both in Egg String Agar and Nutrient Agar. All the plates in ESA with E. coli showed pinpoint, mucoid, white, translucent, punctiform, and entire colonies. On the contrary, NA demonstrated small, mucoid, pale yellow, opaque, circular, and entire colonies in all plates.

Table 4. Colony Morphology of Staphylococcus aureus in Nutrient Agar and Egg String Agar

	Egg String Agar			Nutrient Agar		
	Morphology	**Frequency**	**Percentage**	**Morphology**	**Frequency**	**Percentage**
Size	pinpoint	7	100%	small	1	100%
Surface Appearance	mucoid	2	28.57%	mucoid	1	100%
Color	pale yellow	7	100%	pale yellow	1	100%
Density	opaque	2	28.57%	opaque	1	100%
Form	punctiform	7	100%	punctiform	1	100%
Margin	entire	7	100%	entire	1	100%

Table 4 presents the frequency distribution of the colony morphology of the Staphylococcus aureus both in Egg String Agar and Nutrient Agar. The triplicate plates of ESA with S. aureus showed pinpoint, mucoid, pale yellow, opaque, punctiform, and entire colonies. Meanwhile, NA demonstrated small, mucoid, pale yellow, opaque, punctiform, and entire colonies in all plates.

Colonial Characteristic Evaluation of the Bacterial Growth of Egg String Agar and Nutrient Agar

This portion presents the colonial characteristic evaluation of the bacterial growth of Egg String Agar and Nutrient Agar using Escherichia coli and Staphylococcus aureus as test microorganisms, respectively. The parameters included in this evaluation are based on the colony morphology categories of

Centers for Disease Control and Prevention [CDC] which include, surface appearance, size, color, and shape. A criterion was established by the researchers. A rating of 0 indicates that the quality of a parameter is poor, 1 is of satisfactory quality, and 2 indicates an outstanding quality.

Table 5. Colonial Characteristic Evaluation of *E. coli* Growth on Egg String Agar (ESA) and Nutrient Agar

Variables	Nutrient Agar (Positive Control)		ESA					
			25 mL		50 mL		75 mL	
	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage
Surface Appearance								
0	0	0%	0	0%	0	0%	0	0%
1	0	0%	3	100%	3	100%	3	100%
2	3	100%	0	0%	0	0%	0	0%
Size								
0	0	0%	0	0%	0	0%	0	0%
1	0	0%	3	100%	3	100%	0	0%
2	3	100%	0	0%	0	0%	3	100%
Color								
0	0	0%	2	66.67%	0	0%	0	0%
1	0	0%	1	33.33%	3	100%	3	100%
2	3	100%	0	0%	0	0%	0	0%
Shape								
0	0	0%	1	33.33%	0	0%	0	0%
1	0	0%	2	66.67%	3	100%	1	33.33%
2	3	100%	0	0%	0	0%	2	66.67%

Table 5 shows that the *E. coli* colonial characteristics present in the NA had exhibited outstanding qualities seeing that 100% of the ratings it had received in the four parameters were 2. 100% of the ratings received by all setups under the ESA in the colonial surface appearance category were 1, indicating that ESA has lower qualities than NA. When observing the colonial size category, 100% of the ratings received by setup 1 and setup 2 were 1, while setup 3 received 100% of its ratings as 2. This means that setup 3 is on an equal level with NA in terms of colonial size. In the colonial color category, setup 1 received ⅔ of its ratings as 0 and ⅓ of its ratings as 1. The rest of the setups had received 100% of its ratings as 1. This indicates that all of the setups displayed lower qualities in terms of colonial color when compared to NA. However, when only the 3 setups are compared between each other, it can be inferred that setup 3 has superior qualities. Lastly, when analyzing the colonial shape category, setup 1 received ⅓ of its ratings as 1 and ⅔ of its ratings as 2. 100% of the ratings received by setup 2 were 1. ⅓ of the ratings received by setup 3 were 1 and ⅔ of the ratings received were 2. It can be deduced that setup 3 once again had displayed superior qualities compared to the rest of the setups, but it is still inferior when compared to NA.

Table 6. Colonial Characteristic Evaluation of *S. aureus* Growth on Egg String Agar (ESA) and Nutrient Agar

Variables	Nutrient Agar (Positive Control)		ESA					
			25 mL		50 mL		75 mL	
	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage
Surface Appearance								
0	0	0%	2	100%	3	100%	2	100%
1	0	0%	0	0%	0	0%	0	0%
2	3	100%	0	0%	0	0%	0	0%
Size								
0	0	0%	2	100%	3	100%	2	100%
1	0	0%	0	0%	0	0%	0	0%
2	3	100%	0	0%	0	0%	0	0%
Color								
0	0	0%	2	100%	3	100%	2	100%
1	0	0%	0	0%	0	0%	0	0%
2	3	100%	0	0%	0	0%	0	0%
Shape								
0	0	0%	2	100%	3	100%	2	100%
1	0	0%	0	0%	0	0%	0	0%
2	3	100%	0	0%	0	0%	0	0%

Table 6 shows that the S. aureus colonial characteristics present in the NA had also exhibited outstanding qualities knowing that 100% of the ratings it had received in the four parameters were 2. It can be observed that 100% of the ratings received by all of the setups under ESA in all of the colonial characteristic categories were 0. It can be simply inferred that ESA is not suitable for the growth of S. aureus since it displayed poor colonial characteristics compared to NA.

Confirmatory Tests

To fulfill the fourth [4th] objective of this research, this section demonstrates the presence of bacteria in all culture plates by conducting confirmatory tests on Staphylococcus aureus and Escherichia coli inoculated on the Egg String Agar media. Results of the previously described biochemical tests are presented below.

Table 7. Confirmatory Testing for *Staphylococcus aureus*

Staphylococcus aureus	Plate (mL)	Gram Staining	Catalase Test	Coagulase Test
Positive Control		Gram Positive	+	+
Replicate 1	75 mL	Gram Positive	+	+
Replicate 2	75 mL	Gram Positive	+	+
	25 mL	Gram Positive	+	+
Replicate 3	50 mL	Gram Positive	+	+
	255 mL	Gram Positive	+	+

Table 7 presents confirmatory test results for Staphylococcus aureus on two biochemical testing—Catalase and Coagulase tests which verified its presence on the ESA media. The "+" symbol denotes a positive reaction as well as its presence, while the "-"symbol denotes the absence of it. The presence of Staphylococcus aureus was verified for positive control using the Catalase and Coagulase test techniques. The presence of S. aureus was tested and confirmed in the following volumes of ESA: 75 mL in Replicate 1 and 2; 25 mL in Replicate 2 and 3, and 50 mL in Replicate 3. While the other replicates, which were not presented here in the table, thus have the absence of the growth on the ESA plates.

Table 8. Confirmatory Testing for *Escherichia coli*

Escherichia coli	Plate (mL)	Gram Staining	IMVic			
			Indole	Methyl Red	VP	Citrate
Positive Control		Gram Negative	+	+	-	-
Replicate 1	25 mL	Gram Negative	+	+		
	50 mL					
	75 mL					
Replicate 2	25 mL	Gram Negative	+	+	-	-
	50 mL					
	75 mL					
Replicate 3	25 mL	Gram Negative	+	+	-	-
	50 mL					
	75 mL					

Table 8 displays confirmatory test findings for Escherichia coli using the IMViC test technique which proves its presence on ESA media. The presence of Escherichia coli is indicated by the "+" symbol, whilst its absence is indicated by the "-" symbol. ESA inoculated with E. coli exhibited growth on all volumes [25 mL, 50mL, 75 mL] and the microorganism was confirmed to be E. coli through IMViC and gram staining, which presented positivity for indole and methyl red test and negative reaction was observed in Citrate and Voges- Proskauer test. The results coincide with the bacterial profile of E. coli, verifying its presence in the ESA plates.

Part II. Absolute Growth Index

Addressing the fifth [5th] objective of this research, this section exhibits the AGI scores of the bacterial colonies on each replicate under various setups of the Egg String Agar. The indications of the scores can be found in the next table. These data were then statistically treated to draw out inference from them.

Table 9. AGI of Escherichia coli and Staphylococcus aureus on ESA

Nutrient Agar				25 mL [Setup 1]			50 mL [Setup 2]			75 mL [Setup 3]			
	R1	R2	R3	R1	R2	R3	R1	R2	R3	R1	R2	R3	
E. coli	4	4	4	4	1	1	1	4	4	3.5	1.5	4	
S. aureus	4	4	4	1	1	0	1	1	1	1	1	0	

Table 9 exhibits the AGI of E. coli and S. aureus on each of the replicates of the NA and that of each of the setups of ESA.

Table 10. Absolute Growth Index [AGI]

Growth	AGI
All quadrants	4.0
All in quadrants 1, 2, and 3, but half in quadrant 4	3.5
All in quadrants 1, 2, and 3, but no growth in quadrant 4	3.0
All in quadrants 1 and 2, but half in quadrant 3	2.5
All in quadrants 1 and 2	2.0
Quadrant 1 but half in quadrant 2	1.5
Quadrant 1	1.0
No Growth	0.0

Table 10 presents the absolute growth index utilized by the researchers to give a basis for the scoring of the amount of colonies produced by *E. coli* and *S. aureus* in both Egg String Agar and Nutrient Agar. This method of colony counting was based on a study by Masong et al. about Mung Beans as an alternative culture medium for Trypticase Soy Agar.

Table 11. Comparison between the Absolute Growth Index of *E.coli* in Egg String Agar and Nutrient Agar

	Volume	N	Mean Rank
Absolute Growth Index	Positive Control	3	9.00
	25 mL	3	4.33
	50 mL	3	6.67
	75 mL	3	6.00
	Total	12	

Table 11 shows the mean ranks of the absolute growth index of E. coli growth in the Nutrient Agar as the positive control and in the various setups under the Egg String Agar. The positive control had a mean rank of 9.00, the triplicates of the 25 mL ESA had a mean rank of 4.33, 50 mL had a mean rank of 6.67 and the 75 mL had a mean rank of 6.00.

Table 12. Test Statistics of Table 11

	Absolute Growth Index
Chi-Square	3.277
df	3
Asymp. Sig.	.351

A Kruskal-Wallis H test was utilized to compare the absolute growth index of E. coli between Egg String Agar and Nutrient Agar. The test showed that there was no statistically significant difference in AGI between the different volumes of the [lukot] extract, $\chi 2(2) = 3.277$, $p = 0.351$, with a mean rank AGI of 9.00 for Positive Control, 4.33 for 25 mL, 6.67 for 50 mL, and 6.00 for 75 mL. Upon the analysis of these data, the researchers accepted the null hypothesis. It can be deduced that the mean absolute growth index of E. coli in both ESA and NA does not differ much. Therefore, the conditions provided by the ESA for E. coli growth are comparable to that of NA in terms of AGI.

Table 13. Comparison between the Absolute Growth Index of *S. aureus* in Egg String Agar and Nutrient Agar

	Volume	N	Mean Rank
Absolute Growth Index	Positive Control	3	11.00
	25 mL	3	4.50
	50 mL	3	6.00
	75 mL	3	4.50
	Total	12	

Table 13 shows the mean ranks of the absolute growth index of S. aureus growth in the Nutrient Agar as the positive control and in the various setups under the Egg String Agar. The positive control had a mean rank of 11.00, the triplicates of the 25 mL ESA had a mean rank of 4.50, 50 mL had a mean rank of 6.00 and the 75 mL had a mean rank of 4.50.

Table 14. Test Statistics of Table 13

	Absolute Growth Index
Chi-Square	8.360
df	3
Asymp. Sig.	039

A Kruskal-Wallis H test was also utilized to compare the absolute growth index of S. aureus between Egg String Agar and Nutrient Agar. The test showed that there was a statistically significant difference in AGI between the different volumes of the [lukot] extract, $\chi 2(2) = 8.360$, $p = 0.39$, with a mean rank AGI of 11.00 for Positive Control, 4.50 for 25 mL, 6.00 for 50 mL, and 4.50 for 75 mL. Upon the analysis of these data, the researchers rejected the null hypothesis. It can be deduced that the mean absolute growth index of S. aureus in both ESA and NA considerably differ. Therefore, the conditions provided by the ESA for S. aureus growth are different to that of the NA in terms of AGI.

CONCLUSION

In retrospect, this study successfully explored the potential of egg strings from the wedge sea hare [*Dolabella auricularia*] as a nutrient source for bacterial growth. The findings revealed that bacterial growth on Egg String Agar [ESA] varied with the conventional Nutrient Agar [NA]. While Nutrient Agar supported abundant colonies of Escherichia coli and Staphylococcus aureus, the ESA demonstrated comparatively limited growth. However, the ESA did support growth of both E. coli and S. aureus, with E. coli exhibiting a higher number of colonies compared to S. aureus. Several factors might have contributed to this reduced growth, including potential nutrient deficiencies, egg strings extract concentrations, or the presence of inhibitory substances within the egg strings. These results suggest that while the concept of utilizing egg strings as an alternative nutrient source is promising, further optimization and research are necessary to enhance its effectiveness for bacterial cultivation.

RECOMMENDATIONS

Based on the conclusions presented above, the following are recommended:

1. The researchers recommend the following to the future researchers:
   1.1. add solidification time as a parameter to assess the effectiveness of the ESA;
   1.2. add colony counting as a parameter to assess the bacterial growth of the ESA;
   1.3. measure and compare the pH of the ESA with that of the NA control;
   1.4. increase the concentration of the extract of egg strings in the preparation of the ESA;
   1.5. utilize other nutrient source or extract in addition to the egg string extract in the preparation of the ESA;
   1.6. add other bacterial species as test microorganisms;
   1.7. add more biochemical tests to further differentiate bacterial species;
   1.8. increase the sample size of the specimens and validators in the study;

1.9. compare the financial costs of the formulation of the ESA with that of the NA control;
1.10. utilize other cost-effective materials and equipment;
1.11. consider other efficient methods of pure egg string extraction; and
1.12. perform proximate analysis to have a comprehensive overview of the nutritional and chemical composition of the egg strings extract.

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SENSORY ATTRIBUTE AND NUTRITIONAL ANALYSIS OF BROWNIE COOKIES ENRICHED WITH FRESH MALUNGGAY (*Moringaoliefera*) LEAVES

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ABSTRACT

This is an experimental study aimed to determine the level of acceptability of the brownie cookies enriched with 5, 10, and 15 grams fresh malunggay leaves compared with the plain brownie cookies as to appearance, aroma, taste, texture, volume and general acceptability. Three replications were made for each brownie cookies mixture and were evaluated by 20 students, 20 faculty and 20 homemakers purposely selected respondents. The brownie cookies enriched with fresh malunggay leaves in different proportions was evaluated using a sensory evaluation score sheet based on the Five-Point Hedonic Scale. Arithmetic mean and One-Way Analysis of Variance were used to determine if there were significant differences in the appearance, aroma, taste, texture, volume, and general acceptability of brownie cookies enriched with fresh malunggay leaves. The hypothesis was tested at 0.01 level of significance. Finding revealed that brownie cookies with 5 grams of fresh malunggay leaves were the most acceptable since they were liked extremely by the group of evaluators as to its general acceptability, and very comparable with plain brownie cookies in all sensory characteristics. With these results, it was concluded that no significant difference existed in the level of acceptability of brownie cookies enriched with fresh malunggay leaves in terms of aroma, texture and volume. Significant difference existed in the level of acceptability of brownie cookies enriched with fresh malunggay leaves in terms of appearance, tastes and general acceptability as evaluated by students, teachers and other bakers. It was recommended that further study be conducted on the utilization of other leaves in preparing brownie cookies. Furthermore, results of this study are disseminated to the public for information through trainings, lectures, cooking demonstrations and extension program.

Keywords: Cookies; Fresh Malunggay Leaves; Sensory Attributes

INTRODUCTION

United Nations (UN) Sustainable Development Goal (SDG) No. 2 aims to achieve zero hunger (UN, 2015). One way to achieve SGD No. 2 is to provide people with healthy and nutritious food. Access to nutritious food however remained a challenged. In 2022 alone, it is estimated that a third or 2.2 billion people in the world "could not afford a healthy diet" (FAO, 2024, p. xvi). It is projected by the same UN report that "582 million people will be chronically undernourished" (FAO, 2024, p. xvi)) by the end of 2030. Philippine situation follows global trend. Business World (2024) reported that six in 100 Filipinos or 6.9 million Filipinos are undernourished citing a UN report. The Philippines is ranked 67th among 127 countries in the 2024 Global Hunger Index (GHI). The country's score in GHI is 14.4 indicating moderate hunger. GHI data also showed 5.9 percent of the country's population is undernourished while 26.7 percent of Filipino children are stunted.

A high price is paid by the Philippines due to malnutrition. Nutrition International (Flores, 2025) estimated that the country losses P496 billion per year due to malnutrition alone. The amount is equivalent to 2 – 3 percent of the country's gross domestic product (GDP). This is translated to loss of P1.36 billion a day. It is also estimated by Nutrition International that 3.4 children under five in the Philippines have stunted growth. Stunting is a result of poor nutrition. One way to combat undernourishment and malnutrition in particular and hunger in general is through nutritional supplementation of food. This refers to the preparation of food where a nutrient missing from a diet is added. Food fortification is one

of the strategies of the government to improve the health of the people (Depra, 2011). The government recognized that a simple diet consisting of staple foods is often deficient of certain nutrient thus nutrient supplementation is one its health thrusts.

To institutionalize food fortification, the Philippine government passed the Philippine Food Fortification Act of 2000 or RA No. 8976. The chief aim of the law is to prevent and limit nutritional deficiency in the country. It mandates that additional nutrients should be added to processed foods or food products in accordance with the standards set by the Recommended Dietary Allowances (RDA). This is to fight malnutrition in the Philippines and improve the overall health status of Filipinos. Food fortification is an inexpensive and effective way to reach large populations with essential micronutrients. It is also the most efficient way to maintain or improve the quality of the diet. For developing countries like the Philippines, food fortification is considered as the best food-based approach for solving the nutritional problems.

Commercial food fortification adds trace amounts of micronutrients to foods during processing, which helps consumers achieve the required levels of micronutrients in their diet. This intervention of food improvement is to restore nutrients lost during food processing or food enrichment and to add nutrients that may not be present naturally in food or food fortification. The amount of nutrients added during processing may be higher than the present before processing and it standardized the content of nutrients that show variable concentrations.

Among the nutrients that can be added to food and food products are Vitamin A, Vitamin B6, Vitamin C, riboflavivn, iron, and manganese. The malunggay leaves are rich with these nutrients (NatureClaim, 2025). Adding malunggay leaves to food will provide the mentioned nutrients to people. The challenge is how to encourage people to consume malunggay to get the nutrients from its leaves. One way to do this is to add malunggay leaves as food fortification to a popular food treat. Among these popular food treats is brownies. The popularity of brownies is shown by its global market size of US$106.92 billion in 2024 which is projected to grow to USD 172.58 billion by 2032 (Business Research Insight, 2025).

Adding malunggay leaves to brownies is one way to fortify this popular treat with nutrients. Doing this however raises some issues. What is the amount of malunggay leaves that should be added to brownies to make it acceptable to people? What are the appearance, aroma, taste, texture, volume, and general acceptability of brownie cookies when enriched with fresh malunggay leaves? These are questions this study sought to answer. Determining the right proportion of malunggay leaves to be added to brownies as food fortification that is acceptable to the consuming public is one way to supplement and enrich the food of Filipinos, especially the children. This is one way to counter and eliminate undernourishment and malnutrition in the country and provide Filipinos with healthy diet.

OBJECTIVE OF THE STUDY

The study is primarily conducted to determine the level of acceptability of the brownie cookies enriched with malunggay leaves. Specifically it aimed to find out the acceptability of brownie cookies leaves compared with the plain brownie cookies if added with 5, 10, and 15 grams fresh malunggay leaves. What is the level of acceptability malunggay enriched brownie cookie in terms of appearance, aroma, taste, texture, volume and general acceptability?

METHODOLOGY

The study was an experimental research which utilized Randomized Complete Block Design (RCBD). Brownie cookies mixture was prepared and the amount of fresh malunggay leaves was added in different proportions as variations such as Mixture A-5 grams fresh malunggay leaves, Mixture B-10 grams fresh malunggay leaves, Mixture C-15 grams fresh malunggay leaves and D – 0 grams or no fresh malunggay leaves as the control mixture. Sixty (60) persons composed of (20) HM faculty, (20) homemakers and (20) students from the West Visayas State University, Janiuay Campus were purposely selected as panel of evaluators of the study.

The level of acceptability of the brownies cookies as to the appearance, taste, texture, volume and general acceptability were determined based on Modified Five-Point Hedonic Scale. The matrix used by the evaluators are as follows: 5 - liked extremely, for the highest evaluation; 4 - liked very much for the second highest evaluation; 3 - liked moderately, for the third highest evaluation; 2 - disliked very much, for the fourth highest evaluation; and 1 - disliked extremely, as the lowest evaluation.

The experimental study was divided into four phases. Phase I - preparation fresh malunggay leaves; Phase II - preparation of the brownie cookies; Phase III - mixing of fresh malunggay leaves in different proportions with the cookie mixture; and Phase IV - evaluation of the brownie cookies enriched with different proportions of fresh malunggay leaves by the panel of evaluators.

The finished product was subjected to sensory evaluation by the group of evaluators to identify the level of acceptability of brownie cookies enriched with fresh malunggay leaves in term of appearance, taste, texture, volume and general acceptability. Each evaluator was requested to drink water after every testing of the product to rinse their mouth so that assessments of the taste were satisfied.

After the sensory evaluation of the finished product is done, the score sheets were gathered; responses were recorded, tallied, summarized and prepared for computations. Arithmetic means was used in determining the level of acceptability as to aroma, color, flavor, volume and general acceptability. The computed means were analyzed and interpreted using the following scale: 4.21 to 5.00 – Extremely Liked; 3.41 to 4.20 – Very Much Liked; 2.61 to 3.40 – Moderately Liked; 1.81 to 2.60– Very Much Disliked; and 1.00 to 1.80 – Extremely Disliked.

To determine whether a significant difference exist in the level of acceptability of brownie cookies in different proportions, the One-Wway Analysis of Variance was computed, set at 0.01 level of significance.

FINDINGS

Discussed in the succeeding section of the paper are the findings of the study. The different proportions of brownie cookie mixed with malunggay leaves were evaluated as to their level of acceptability in terms of appearance, aroma, taste, texture, volume and general acceptability.

Appearance

Appearance is its color and physical aspect of the brownie cookies with fresh malunggay in which it is usually viewed in varied ways by different people, its visual presentation without the use of touch and much less of taste. Appearance is determined by color, size, shape, surface characteristics, interior appearance and general arrangement of the food (De Leon, 1999).

Color is considered as the appearance factor that plays a good role in the product. It is a component that will forever be a part of food in which the human eyes, mind, emotions and plates can become sensitive (Gatchalain, 1989: 28).

Table 1. Mean Rating of Brownie Cookies with Fresh Malunggay in Different Proportions as to Appearance

Proportions	Mean	Interpretation
A – 0 gms. fresh malunggay leaves	4.53	Liked extremely
B – 5 gms. fresh malunggay leaves	4.27	Liked extremely
C – 10 gms. fresh malunggay leaves	4.17	Liked very much
D – 15 gms. fresh malunggay leaves	4.02	Liked very much

The obtained mean for the different proportions are as follows: Proportion A (brownie cookies mixture with 0 gms. fresh malunggay leaves) - 4.53; Proportion B (brownie cookies mixture with 5 gms. fresh malunggay leaves) - 4.27; Proportion C (brownie cookies mixture with 10 gms. fresh malunggay leaves) - 4.17; and Proportion D (brownie cookies with 15 gms. fresh malunggay leaves) - 4.02. This means that Proportion A and B was “Liked Extremely” while Proportions C and D was “Liked Very Much” by the group of respondents. Result implies that the appearance of Proportion A and B was extremely liked by the respondents for it looks very rich, golden brown and the color is light yellow.

The result of the study is the same as the findings of De Leon (1999). Appearance according to her is the physical aspect of the malunggay brownie cookies in which it is usually viewed in varied ways by different people. It is a visual presentation without the use of touch and much less of taste. Appearance

is determined by color, size, shape, surface characteristics, interior appearance and general arrangement of the food. Based on the study results it is implied that the appearance of Proportion A and B was extremely liked by the respondents because it looks very rich, golden brown and the color is light yellow.

An earlier finding was reported by Gatchalian (1989) on the color. Color is considered as the appearance factors that plays a good role in the product. It is a component of food in which the human eyes, mind, emotions and plate can became sensitive. Similar finding was revealed by Dollete (1996) on the appearance of Pastillas de nangka which was "liked very much" by the group of non-teaching personnel and "liked moderately" by the group of culinary arts teachers.

Table 2. ANOVA for Appearance of Brownie Cookies with Fresh Malunggayin Different Proportions

Source of Variance	Sum of Squares	df	Mean Sum of Squares	F Value	P Value
Between Groups	8.512	3	2.837	6.440*	.000
Within Groups	103.983	236	.441		
Total	112.496	239			

P < = 0.01

One-Way ANOVA of 6.440 with a p-value of 0.000 indicated significant difference in the level of acceptability of brownie cookies with fresh malunggay in different proportions in terms of appearance. This means that the appearance of the product as determined by color, shape and size and the general arrangement of the food differ from one product to another. The null hypothesis which states that there is no significant difference in the level of acceptability of brownie cookies with fresh malunggay leaves in different proportions was not accepted.

The findings conform to research results reported by Warner and Inglett (1997) showing that appearance of baked products are affected by types and amounts of fat used. Result however does not conform to that of Rodriguez on the nutritional value and level of acceptability of pandesal using different proportions of mango. Her study revealed that there was no significant difference in the color of pandesal using different proportions of mango flour and wheat flour. Another result was that of Roldan (2003). Her findings revealed no significant difference on the appearance of muffins prepared from 75%t all-purpose flour and 25% squash flour and 50% all-purpose flour and 50% squash flour.

Aroma

Aroma is recognized by the sense of smell. The aroma may be sweet, rich, musty, or flat. The deal aroma should be pleasant, fresh, sweet and natural. Sharp, bitter or foreign aroma is undesirable.

Table 3. Means Rating of Brownie Cookies with Fresh Malunggay in Different Proportion as to Aroma

Proportions	Mean	Interpretation
A – 0 gms. fresh malunggay leaves	4.33	Liked extremely
B – 5 gms. fresh malunggay leaves	4.17	Liked very much
C – 10 gms. fresh malunggay leaves	4.25	Liked extremely
D – 15 gms. fresh malunggay leaves	4.15	Liked very much

The obtained mean for the different proportions are as follows: Proportion A (brownie mixture with 0 gms. of fresh malunggay leaves) - 4.33; Proportion B (brownie mixture with 5 gms. of fresh malunggay leaves) - 4.17; Proportion C (brownie mixture with 10 gms. of fresh malunggay leaves) - 45.5; and Proportion D (brownie mixture with 15 gms. of fresh malunggay leaves) - 4.15. This means that Proportion A and C as well as Proportion B and D were "liked extremely" implying that the aroma of Proportion B and D was liked extremely due to distinct smell, pleasing odor, and agreeable odor.

In the study of Roland (2003), out of four proportions of squash brownie mixtures, Preparation B (50% all-purpose flour and 50% squash flour) was liked extremely and acceptable to the evaluators. Similar findings were shown by the study of Ortigas (1999). Results revealed that the aroma of formulation H2 with 50% honey 50% sucrose and formulation G2 with 50% glucose and 50% sucrose were most acceptable. De Guzman (1983) in her study of bread made from banana flour substituting at 10 and 15 percent proportion approximated the bread made from wheat flour.

Finding also conforms to the study of Hontanar (2002) on the aroma of palawan fries. Palawan fries were characterized by its not apparent odor. The study showed that the product was liked very much by the students while the teachers and parents liked moderately the smell of the product. A similar finding

was found by the study of Miravilles (2000) on the aroma of kondol candies which were characterized by the absence of an off-odor which refers the smell of the candy.

Table 4. ANOVA for Aroma of Brownie Cookies with Fresh Malunggay Leaves in Different Proportions

Source of Variance	Sum of Squares	Df	Mean Sum of Squares	F Value	P Value
Between Groups	1.283	3	.428	.662*	.576
Within Groups	152.567	236	.646		
Total	153.850	239			

P > .01

The One-Way ANOVA of 0.662 with a p-value of 0.576 reveals no significant difference in the level of acceptability of brownie cookies with fresh malunggay leaves in different proportions in terms of aroma. This suggests that the smell of the products does not differ from one another as evaluated by the group of respondents. The aroma of the products was almost the same. The null hypothesis was accepted.

These findings conform to the results of Jimenez (2005) study on crusty tart using different proportions of cornstarch. Her study revealed that as to aroma, there was no significant difference on the level of acceptability of crusty tart.

Taste

Taste is a chemical sense that allows human to process information through different sensations such as sweet or salty as well as texture (Huffman). The sense of taste as well as texture and visual appeal all drive a child to eat (or not eat) in much the same was as adults.

Table 5. Mean Rating of Brownie with Fresh Malunggay Leaves in Different Proportions as to taste

Proportions	Mean	Interpretation
A – 0 gms. fresh malunggay leaves	4.50	Liked extremely
B – 5 gms. fresh malunggay leaves	4.30	Liked extremely
C – 10 gms. fresh malunggay leaves	4.03	Liked extremely
D – 15 gms. fresh malunggay leaves	3.39	Liked extremely

The obtained mean for the different proportions are as follows: Proportion A (brownie cookies mixture with 0 gms. of fresh malunggay leaves) - 4.50, Proportion B (muffin mixture with 5 gms. of fresh malunggay leaves) - 4.30; Proportion C (brownie cookies mixture with 10 gms. of fresh malunggay leaves) - 4.03; and Proportion D (brownie cookies mixture with 15 gms. of fresh malunggay leaves) - 3.95. This denotes that Proportion A and B was "liked extremely" while Proportions C and D was "like very much" by the group of respondents. Result indicates that the taste of Proportion of A and B were liked extremely by respondents because the flavor which is one of the sensory attributes resulting from a combination of the taste and aroma.

Alimo-ot (2006) studied cookies out of potato flour. Her study revealed that treatments C, D and E were liked extremely by the respondents. These results implied that treatment C (50% all-purpose flour and 50% potato flour) and Treatment D (75% all-purpose flour and 25% potato flour) were comparable to Treatment E (100% all- purpose flour). A similar study of Demingoy (1984) showed that the desirable taste of cake made from camote flour as substitute flour for commercial flour was acceptable to the evaluators. Guilergan (1989) in her study on the use to the three varieties of bananas namely: saba, latunda and manilan-on revealed that as to flavor, the 40% and 60% proportion of latundan banana was liked better by the evaluators.

Table 6. ANOVA for Taste of Brownie Cookies with Fresh Malunggay Leaves in Different Proportions

Source of Variance	Sum of Squares	Df	Mean Sum of Squares	F Value	P Value
Between Groups	11.42	3	3.804	6.993	.000
Within Groups	128.383	236	.544		
Total	139.796	239			

P < .01

Computed Analysis of Variance at 6.993 with a p-value of 0.000 implies that there is a significant difference in the level of acceptability of brownie cookies with fresh malunggay leaves in different proportions in terms of taste. This suggests that the taste of the brownie cookies in different proportions significantly varies from one another. The null hypothesis was rejected.

Roldan (2003) revealed similar results. As to taste, significant difference existed between Preparation A (25% mashed squash and 75% all-purpose flour) and Preparation C (75% squash flour and 25% all-purpose flour) brownie cookie out of squash. Sinoben (2004) in his study revealed different results. The three groups of evaluators have the same perception on the taste the pandesal enriched with carrot puree in different proportions.

Texture

Texture depends on the physical condition of the crumb and is influenced by the grain. Desirable brownie cookies should be easily broken and slightly crumbly. Extremely crumbling and toughness with lack of crumbling are undesirable characteristics.

Table 7. Mean Rating of Brownie Cookies with Fresh Malunggay Leaves in Different Proportion as to Texture

Proportions	Mean	Interpretation
A – 0 gms. fresh malunggay leaves	4.52	Liked extremely
B – 5 gms. fresh malunggay leaves	4.22	Liked very much
C – 10 gms. fresh malunggay leaves	3.83	Liked very much
D – 15 gms. fresh malunggay leaves	4.00	Liked extremely

As shown in the table, the obtained mean of Proportion A (brownie cookies mixture with 0 gms. of fresh malunggay leaves) was 4.52; Proportion B (brownie cookies mixture with 5 gms. of fresh malunggay leaves) was 4.22; Proportion C (brownie cookies mixture with 10 gms. fresh malunggay leaves) was 3.83; and Proportion D (brownie cookies mixture with 15 gms. of fresh malunggay leaves) was 4.00. This means that Proportions A and D were "liked extremely" while Proportions B and C were "liked very much" by the group of respondents. This implies that the texture of Proportions A and D were liked extremely by the respondents because it soft and moist.

These findings were similar with the findings of Jemina (1996) on the acceptability of saba choco milk candy, saba cheese sticks, saba coconut balls, sabasakoy nuts and raisin bars, saba nangka bars, pasta de saba, pastillas de saba, saba pineapple delight, saba polvoron and saba yema prepared from unripe saba. Results showed that the texture of the products from saba were acceptable to the evaluators.

The study of Guillergan (1989) reported that as to texture, the better liked banana muffin is made out of forty to sixty per cent proportions of latundan banana and wheat flour. The study of Demingoy (1984) revealed that the desirable taste of cake made from camote flour as substitute flour from commercial was acceptable in terms of its taste.

In preparing crusty tart in different proportions of cornstarch, Jimenez (2005) reported that Treatment A (75% cornstarch, and 25% all-purpose flour) was liked moderately, while Treatment B (50% cornstarch and 50% all-purpose flour) and Treatment C (25% cornstarch and 75% all-purpose flour) was liked very much by the respondents. Treatment B and C were acceptable and comparable with Treatment D (100% all-purpose flour).

Table 8. ANOVA for Texture of Brownie Cookies with Fresh Malunggay Leaves in Different Proportion

Source of Variance	Sum of Squares	Df	Mean Sum of Squares	F Value	P Value
Between Groups	15.683	3	5.228	10.870*	.000
Within Groups	113.500	236	.481		
Total	129.183	239			

ANOVA value of 10.870 with a p-value of 0.000 signifies there is a significant different in the level of acceptability of brownie cookies with fresh malunggay leaves in different proportions in terms of texture. This implies that the texture of the brownie cookies with fresh malunggay leaves in different proportions as evaluated by the group of respondents differs from one another. The null hypothesis was not accepted.

Dadivas (2008) findings revealed the opposite of the study's finding. She reported that Treatment XY, LM, GH, DP and ST were liked very much and acceptable to the panel of evaluators in terms of appearance, aroma, flavor and texture. With these results, it was concluded that no significant difference existed in the level of acceptability as evaluated by the teachers, students and non-teaching staff.

These findings conformed to the study of Ortiga (1999) on the effect of sugar substitute on the sensory quality of Tiessa Candy Bar. The result showed that significant difference in terms in formulation H@ with 50% honey and 50% sucrose and formulation C2 with 50% glucose and 50% existed.

Volume

Volume refers to the space occupied by a substance. This is mathematically expressed as height x width x length. It is expressed in terms such as cups, quarts, gallons, and liters. Volume is most commonly used to measure liquid. It may also be used for dry ingredients when the amount is too small to be weighted accurately.

Compact brownie cookies with small cells or large brownie cookies with peaked tops and tunnels are undesirable in all types of brownie cookies. Diameter is a more important criterion than volume for evaluating flat-topped brownie cookies. For bell-topped shaped brownie cookies, volume can be evaluated objectively by measuring the height and width of the brownie cookies and measure calculating the volume. To determine the height and width, measure the height point, then slice off the top of the brownie cookies and measure the diameter of the brownie cookie. The volume also can be directly measured big (National Manufacturing Lincoln, Nebraska).

Table 9. Mean Rating of Brownie Cookies with Fresh Malunggay Leaves in Different Proportions as to Texture

Proportions	Mean	Interpretation
A – 0 gms. fresh malunggay leaves	4.38	Liked extremely
B – 5 gms. fresh malunggay leaves	4.18	Liked very much
C – 10 gms. fresh malunggay leaves	4.28	Liked extremely
D – 15 gms. fresh malunggay leaves	4.19	Liked very much

The obtained mean for the different proportions of brownie mixture as follows: Proportion A (brownie cookies mixture with 0 gms. of fresh malunggay leaves) - 4.38; Proportion B (brownie cookies with 5 gms. of fresh malunggay leaves) - 4.18; Proportion C (brownie cookies with 10 gms. of fresh malunggay leaves) - 4.28 and; Proportion D (brownie cookies with 15 gms. of fresh malunggay leaves) - 4.19. This means that Proportions A and C were "like extremely" while Proportions B and D were "liked very much" by the group of respondents. This implies that the Proportion A and C were liked extremely by the respondents because the height and width of the brownie cookies is large but not airy.

Table 10. ANOVA Table for Volume of Brownie Cookies with Fresh Malunggay Leaves in Different Proportion

Source of Variance	Sum of Squares	Df	Mean Sum of Squares	F Value	P Value
Between Groups	1.650	3	.550	1.268*	.268
Within Groups	102.333	236	.434		
Total	103.983	239			

P> 0.01

Computation of Analysis of Variance yielded a value of 1.268 with a p-value of 0.286. This implies that there is no significant difference in the level of acceptability of brownie cookies with fresh malunggay leaves in different proportions in terms of volume. This also suggests that volume brownie cookies mixture with 0 gram, 5 grams, 10 grams, and 15 grams fresh malunggay leaves were alike in terms of height and width. Therefore the null hypothesis was accepted.

General Acceptability

General acceptability is the state of being satisfactory, capable, worthy, or sure of being accepted or received with pleasure, pleasing to a receiver, gratifying, agreeable and welcome as an acceptable present. It also refers to the reaction of the evaluating panel towards acceptability of brownie cookies with different proportions of fresh malunggay leaves.

Table 11. Mean Rating of Brownie Cookies with Fresh Malunggay Leaves in Different Proportions as to General Acceptability

Proportions	Mean	Interpretation
A – 0 gms. fresh malunggay leaves	4.67	Liked extremely
B – 5 gms. fresh malunggay leaves	4.42	Liked extremely
C – 10 gms. fresh malunggay leaves	4.27	Liked extremely
D – 15 gms. fresh malunggay leaves	4.20	Liked very much

The obtained mean of brownie cookies mixture from different proportions are as flows: Proportion A (brownie cookies mixture with 0 gms. of fresh malunggay leaves) - 4.67; Proportion B (brownie cookies mixture with 5 gms. of fresh malunggay leaves) - 4.42; Proportion C (brownie cookies mixture with 10 gms. of fresh malunggay leaves) - 4.27; and Proportion D (brownie cookies mixture with 15gms. of fresh malunggay leaves) - 4.20. This means that Proportion A, B and C were "liked extremely" while Proportion D "liked very much" by the group of respondents. Results indicate that the general acceptability of Proportions A, B and c were liked extremely by the respondents because the product is acceptable in terms of appearance, aroma, taste, texture and volume.

These findings conform to the study of Rodriguez (2000). Results revealed that the shape, size and color of Treatment D got the highest average rating. She concluded that there was no significant difference in the level of acceptability of pandesal using different proportions of monggo flour and wheat flour. The study conforms to the acceptability test of Barganza (2002). Results of the test revealed that consumers liked very much the sample with the total responses of 44. The results further revealed that the product was very much accepted by customer panel.

This result is the same with the results of Roland (2003). Her results revealed the Proportion D (50% squash flour and 50% all-purpose flour) is the most acceptability. The findings further showed that there is a significant difference between Proportion A and C (75% squash flour and 25% all-purpose flour) in terms of general acceptability. Findings are also similar with that of Sinoban (2004) where results showed that Treatment A, B and C of pandesal enriched with carrot puree was liked very much and acceptable of the students, teachers and housewives in terms of color, volume, crust, flavor and aroma and general acceptability.

Table 12. ANOVA for the General Acceptability of Brownie Cookies with Fresh Malunggay Leaves in Different Proportion

Source of Variance	Sum of Squares	Df	Mean Sum of Squares	F Value	P Value
Between Groups	5.477	3	1.826	7.581*	.000
Within Groups	54.880	236	.233		
Total	60.357	239			

$P < 0.01$

Analysis of Variance was computed at 7.851 with a p-value of 0.000 means that there is a significant difference in the level of acceptability of brownie cookies with fresh malunggay leaves in different proportions in term of general acceptability. Therefore, the null hypothesis was not accepted.

This results in the same with the report of Roland (2003). Her results revealed that a proportion B (50:50) is the most acceptable among the four proportions as to general acceptability. The findings further showed that there is a significant difference between Proportions A and C (75% squash and 25% all -purpose flour) in terms of general acceptability.

CONCLUSIONS

Based on the results and findings of the study, the following conclusions are drawn:

1. Brownies cookies with 5 grams of fresh malunggay leaves were the most acceptable since they were liked extremely by the group of evaluators as to its general acceptability, and very comparable in all sensory characteristics.
2. There was no significant difference in the level of acceptability of brownie cookies in different proportions of fresh malunggay leaves in terms of aroma, texture and volume therefore the null hypothesis was accepted.
3. There was a significant difference in the level of acceptability of brownie cookies in different proportions in terms of texture and general acceptability, therefore the null hypothesis was not accepted.

RECOMMENDATIONS

Based on the findings and conclusions of the study the following are its recommendations:

1. Research results are disseminated to encourage students, teachers and homemakers in the community, restaurants, school canteens, day care and hospitals to utilize the brownie cookies for consumption.
2. Farmers should be encouraged to plant more malunggay tree to be used in processing brownie cookies with fresh malunggay leaves.
3. Parents should be encouraged to introduce to their children to eat nutritious and healthy cookies that will satisfy everyone's diet.
4. Further study should be pursued to test the quality, standardization and the preservation period for larger shelf life of the brownie cookies enriched with fresh malunggay leaves.
5. Similar studies are conducted using different proportion of fresh malunggay leaves for brownie cookies making and for other sensory qualities.

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ANTIMICROBIAL ACTIVITY OF *Averrhoa bilimbi* EXTRACTS FROM FRUIT, ROOT, STEM, AND BRANCH AGAINST *Staphylococcus aureus* AND *Escherichia coli*.

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ABSTRACT

The study assessed the antimicrobial properties of Averrhoa bilimbi fruit, root, stem, and branch extracts against the gram-positive bacteria *Staphylococcus aureus* and the gram-negative bacteria *Escherichia coli*. Specifically, it aimed to determine the efficacy of various plant extract concentrations, measure inhibition zone diameters, identify the plant part with the largest inhibition zone, and assess the potential bacterial antimicrobial resistance. Plant parts were collected from Lapu-Lapu City, Cebu, Philippines, authenticated by the Department of Agriculture, and prepared through washing, drying, grinding, and ethanol extraction. Antimicrobial activity was tested using the Kirby-Bauer disc diffusion method. Results showed that *Averrhoa bilimbi* extracts were largely ineffective against both bacteria, with no significant zones of inhibition, indicating bacterial resistance. Among the extracts, the root had the largest inhibition zone against *Staphylococcus aureus*, though still insufficient to be considered effective. No inhibition zones were observed for *Escherichia coli* across all plant parts and extract concentrations, demonstrating the bacteria's resistance to plant extracts. Statistical analysis revealed significant differences in inhibition zone diameters across extract concentrations, leading to the rejection of first null hypothesis. Comparisons with both positive and negative further supported the alternative hypothesis that *Averrhoa bilimbi* extracts have distinct but ineffective antimicrobial effects. Despite some variability, the extracts failed to significantly inhibit the growth at tested concentrations. This emphasizes the need for additional research into higher concentrations or different extraction methods, or other potential antimicrobial agents. This study contributes to microbiological knowledge on plant-based antimicrobials and the challenges in developing effective treatments.

Keywords: Microbiology, Antimicrobial susceptibility testing, Kirby-Bauer disc diffusion method, Antimicrobial properties, Zone of inhibition, Plant extracts, Antimicrobial resistance, Ethanol extraction, Averrhoa bilimbi, Staphylococcus aureus, Escherichia coli

INTRODUCTION

In the world of medicine, plants with medicinal qualities play a crucial role, providing the raw materials for about 25% of prescribed medications. This research focuses on studying extracts from a specific medicinal plant, *Averrhoa bilimbi* known as Kamias or Iba in Filipino, to understand their effectiveness against harmful bacteria. The plant Averrhoa bilimbi is mostly found in tropical and subtropical areas worldwide, where it is commonly used to treat various diseases like diabetes, hypertension, and infections (Alhassan & Ahmed, 2016). Locally, it is used to relieve coughs due to its very sour taste. The ability of this plant to reduce swelling is crucial in understanding their potential to fight against harmful microorganisms.

A previous study conducted by Muhammad Ecy Prastiyanto et al., 2020 about the antibacterial activity of various extracts of Averrhoa bilimbi has already shown promising outcomes for Averrhoa

bilimbi in terms of their fruit extracts inhibiting the growth of bacteria harmful to humans (Seebaluck-Sandoram et al., 2019). However, the specific characteristics of their roots, stems, and branches, which are important to identify, have not been thoroughly proven. Moreover, only a limited number of studies in the Philippines have explored the antimicrobial properties of these plants. Given the potential for bacteria to develop resistance to antibiotics, it is crucial to determine if the concentrations of the extracts still effectively prevent the growth of microorganisms, especially those that pose a threat to humans. Therefore, the aim of this study is to investigate the antibacterial capabilities of Averrhoa bilimbi root, stem, and branch extracts, and testing the previous concentrations of fruits extracts used to inhibit bacterial growth, assessing their effectiveness against harmful bacteria.

This study is supported by Mie theory of Gustav Mie states that the surface plasmon [LSPR] of a nanoparticle is highly dependent on its size and shape. Therefore, by fabricating nanostructures with varying sizes and shapes, the surface plasmon can be tuned to a distinct wavelength. (Kosuda and Guarke, 2016). Averrhoa bilimbi contain chemical properties such as flavonoids, phenolic acids, terpenoids, silver nitrate and free silver ions. It exhibits antimicrobial properties that can eliminate bacterial pathogens like Staphylococcus aureus and Escherichia coli (Hublikar et al., 2023). In addition, A. bilimbi species has an ascorbic acid property and is rich in vitamin C which can reduce, neutralize and act as a reactive oxygen which forms ascorbate radical and electron. In comparison to the Mie theory, Hartree-Fock self-limiting method explains Electron many-electron system correlations arise due to uncorrelated motion between electrons in the same direction, requiring techniques beyond self-consistent approaches. The Resonance theory by Werner Heisenberg states that there are certain molecules or polyatomic ions that cannot be expressed by a single Lewis formula, therefore it is represented by different resonance structures. This explains the relationship of this theory to the chemical structure and nanoparticles present in the species A. bilimbi.

Antimicrobial Resistance Theory involves the resistance of certain antibiotics because of plasmids, which is done through horizontal transfer of antibiotic resistance genes. This causes a potential threat in health care because of its resistance, which affects humans through time (Castañeda-Barba, 2024). Antibiotics are used to treat illnesses that can lead to death and through time these antibiotics change the composition of pathogens that can lead to adaptation and mutations, and this causes the bacteria to become resistant to the antibiotics that are prescribed. Some bacteria have the capability to make antibiotics ineffective and change their structures and receptors so that they can prevent the antibiotics from attaching to them.

This research study explores the antibacterial properties of extracts from Averrhoa bilimbi's fruits, stems, roots, and branches by using precise measurement methods. The investigation will take place in a carefully controlled laboratory environment. The focus of this study will be on testing the effectiveness of the extracts from different parts of the plant against two types of bacteria: gram-positive (represented by Staphylococcus aureus) and gram-negative (represented by Escherichia coli). The researchers will be carefully gathering plant samples from specific parts, extracting their substances, and then evaluating their ability to fight bacteria using a method called the Disc Diffusion Method (Kirby-Bauer Method). To make sense of the results, researchers will use statistical analysis, specifically ANOVA (Analysis of Variance), with the help of the IBM-SPSS software. This analysis aims to compare how effective the different extracts from various plant parts are at stopping the growth of microorganisms. Lastly, the researchers will also be identifying significant relationships between the concentration of active compounds in the extracts and their ability to fight bacteria. Through the evaluation of the effectiveness of current extract concentrations, the study seeks to offer valuable insights that may lead to the development of more sustainable alternatives to expensive chemically made antibacterial drugs.

STATEMENT OF THE OBJECTIVES

The persistent development of antibiotic resistance in pathogenic bacteria poses a serious threat to public health and calls for a regular review of the antimicrobial drugs currently in use, thus investigating different sources of antibacterial qualities becomes crucial in this situation. Notably, certain plant species have shown promising antibacterial properties, providing a viable way to counteract bacterial resistance. However, despite previous studies revealing the antimicrobial potential of some plants, like

Averrhoa bilimbi, these studies have mainly focused on certain plant parts, most notably the fruits and leaves.

The study aimed to determine the antimicrobial property of *Averrhoa bilimbi* fruit, root, stem and branch extracts as well as its potential against *Staphylococcus aureus* and *Escherichia coli*.

Specifically, it aimed to:

1. To determine the effectiveness of different plant extract concentration against *Staphylococcus aureus* and *Escherichia coli*.
2. To determine the diameter of the zone of inhibition of *Averrhoa bilimbi* against *Staphylococcus aureus* and *Escherichia coli*.
3. To determine what plant part has the largest diameter of zone of inhibition against *Staphylococcus aureus* and *Escherichia coli*.
4. To determine if *Staphylococcus aureus* and *Escherichia coli* exhibit antimicrobial resistance against the plant extracts.

Statement of Hypothesis

Null Hypothesis (H0): *Averrhoa bilimbi* fruit, root, stem, and branch extracts cannot inhibit the growth of the gram-positive bacterium *Staphylococcus aureus* and the gram-negative bacterium *Escherichia coli*.

H01: There is no significant difference between the mean diameter of the Zone of Inhibition (ZOI) of various concentrations of *Averrhoa bilimbi* fruit, root, stem, and branch extracts on the gram-positive bacterium Staphylococcus aureus and the gram-negative bacterium Escherichia coli.

H02: There is no significant difference between the mean ZOI of *Averrhoa bilimbi* fruit, root, stem, and branch extracts and the ZOI of the positive control and the negative control against *Staphylococcus aureus* and *Escherichia coli*.

Alternative Hypothesis (HA): *Averrhoa bilimbi* fruit, root, stem, and branch extracts can inhibit the growth of the gram-positive bacterium Staphylococcus aureus and the gram-negative bacterium Escherichia coli.

HA1: There is a significant difference between the mean diameter of the Zone of Inhibition (ZOI) of various concentrations of *Averrhoa bilimbi* fruit, root, stem, and branch extracts on the gram-positive bacterium *Staphylococcus aureus* and the gram-negative bacterium *Escherichia coli*.

HA2: There is a significant difference between the mean ZOI of *Averrhoa bilimbi* fruit, root, stem, and branch extracts and the ZOI of the positive control and the negative control against Staphylococcus aureus and Escherichia coli.

METHODOLOGY

Research Design

This study constitutes a quasi-experimental research design, thus a thorough investigation conducted in a controlled laboratory setting to delve into the antimicrobial capabilities inherent in extracts derived from *Averrhoa bilimbi* against gram positive (*Staphylococcus aureus*) and gram negative (*Escherichia coli*). The initial phase of the research involved a meticulous collection of plant specimens encompassing an array of parts—fruits, stems, branches, and roots—from diverse sources, ensuring a wide spectrum of bioactive compounds for subsequent analysis. The extraction process encompassed various methodologies and solvents tailored to each plant part to capture and isolate these diverse compounds effectively. To assess the antimicrobial *Averrhoa bilimbi* antimicrobial qualities, the Antimicrobial Susceptibility Testing (AST) which is the Kirby Bauer Method (Disc Diffusion Method) was employed to precisely ascertain the potency of these chosen extracts against the targeted bacterial strains. Statistical analysis—Analysis of Variance (ANOVA) using SPSS software was used to compare and contrast the antimicrobial efficacy across different extracts obtained from various plant parts, seeking correlations between the concentration of bioactive compounds and their resulting antimicrobial activity.

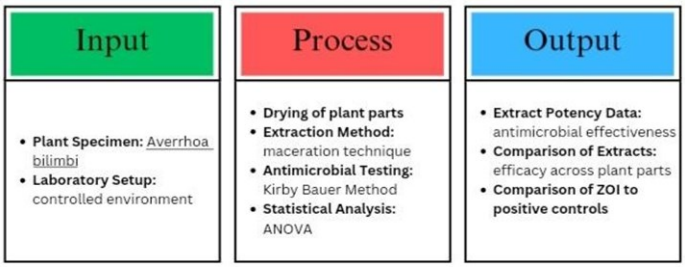

Figure 1. Research flow

This figure represents the IPO model outlining the systematic approach used to investigate the antimicrobial properties of Averrhoa bilimbi extracts.

Research Environment

The study first took place at the house of one of the researchers, Anjelyn Abayon, where the plant, Averrhoa bilimbi, was obtained and prepared for drying. The following processes were then held at the microbiology laboratory of the University of Cebu - Banilad Campus College of Medical Technology, located on the eighth floor. In this room, facilities needed to actualize the study are present. Some procedures that will utilize other equipments such as the Rotary Evaporator (ROTAVAP) that is not available within University of Cebu Banilad Campus will be held at University of San Carlos - Talamban Campus (refer to Appendix D: Location Map).

Research Instrument

To get the appropriate data and results, confirmation was made by the Department of Agriculture [DA] to confirm the authentication of the plant species that was used in this study. The collected plant parts were then air dried at room temperature for 3 days and were additionally dried in the dry oven at 46 degrees Celsius for 4 hours. For the extraction process, the researchers utilized the maceration technique which is a simple extraction method that involves soaking the plant prepared raw material in a solvent of interest, in this case is 95% Ethanol, at room conditions with intermittent agitation, and the Rotary Evaporator [ROTAVAP] of the University of San Carlos - Talamban Campus was then used to evaporate the solvent used (ethanol) to isolate the 100% plant extract. To test the antimicrobial properties of the A. bilimbi, Antimicrobial Susceptibility Testing [AST] using the Kirby Bauer Method or also known as the disc diffusion method was used, where the zones of inhibition were measured using a vernier caliper. Thus, the culture preparation was done through subculturing the indicated bacterial species in Tryptone Soy Agar [TSA].

This research employed a quasi-experimental design, conducted within a controlled lab setting, to explore the antimicrobial potential of Averrhoa bilimbi extracts against Staphylococcus aureus and Escherichia coli. Before analysis, the collected plant parts underwent thorough validation by the Environmental Management Bureau, ensuring their correct classification and authenticity. Thus, this stringent process aimed to accurately identify the plants, ensuring a diverse range of bioactive compounds for more reliable findings.

With the use of the maceration technique and the rotary evaporator (ROTAVAP), this ensured the proper extraction of the plant extracts. The maceration technique is a simple extraction method that involves soaking the plant prepared raw material in a solvent of interest at room conditions with intermittent agitation. This method is commonly used to extract plant materials with organic solvents, such as ethanol. The rotary evaporator was utilized on the other hand to evaporate the excess ethanol after the extraction process to ensure a pure extract will be obtained without the ethanol which can interfere/affect with the results of the Antimicrobial Susceptibility Testing. Furthermore, the use of the Kirby Bauer Method for Antimicrobial Susceptibility Testing ensured precise assessment of the extracts' potency against specific bacteria. The susceptibility testing was done 2 times to ensure that the results will be accurate and reproducible. Then the average zone of inhibition measurement of the trials was then obtained. Analysis via ANOVA in SPSS software enhanced the study's robustness by correlating bioactive compound concentrations with antimicrobial effectiveness across various plant extracts.

The study's validity was further strengthened by a standardized suspension, compared to 0.5 MacFarland standard and the usage of commercial antibiotics to serve as control, ensuring that the results are consistent and dependable. Moreover, the accuracy of bacterial strains, sourced from the rigorously tested Microbiology Department of the University of Cebu Medical Center, confirms their taxonomic classification, affirming the research's credibility regarding antimicrobial properties. These meticulous approaches in research design, methodology, and bacterial sourcing collectively bolster the validity and credibility of the study's findings.

Research Procedures

Before conducting any research study, obtaining an ethics approval sheet/clearance was essential to ensure compliance with institutional and ethical standards. Permission to conduct the study was obtained through a systematic process, starting with approval from relevant authorities at the research locale or institution. This involved submitting a detailed research proposal for review by the University of Cebu Academic Research Ethics Committee (UCAREC). The study did not involve human participants, thus, upon receiving approval, the researchers were able to start their research immediately.

Data Gathering

Averrhoa bilimbi fruits, roots, stems, and branches were freshly obtained from the household of the researcher, Anjelyn Abayon, in Lapu-Lapu City, Cebu, Philippines. The following plant parts were then sent to the Department of Environmental and Natural Resources for authentication. The plant parts were thoroughly washed with tap water, followed by distilled water, and left to air dry for three days. However, due to the cold and rainy weather conditions, they were further dried in a dry oven for 4 hours at 46 degrees Celsius at the Microbiology Laboratory of the College of Medical Technology at the University of Cebu - Banilad. Once completely dried, the roots, stems, and branches were sliced and processed in a food processor before being ground using a laboratory mortar and pestle. Similarly, the fruits were ground using a laboratory mortar and pestle. The processed plant parts were then placed in separate sterile beakers for each part, each containing a 500mL solution of 95% ethanol. They were allowed to soak for 48 hours before being filtered using Whatman Grade 1 qualitative filter paper. The filtrate was collected in sterile glass jars for storage before transport.

At the University of San Carlos - Talamban Campus, a rotary evaporator (ROTAVAP) was utilized for the extraction of processed plant parts. This extraction process aimed to isolate bioactive compounds from the plant materials, following established protocols. Initially, the plant material was subjected to solvent extraction using 95% ethanol. The resulting extract was then concentrated using the rotavap under reduced pressure and controlled temperature conditions, facilitating the removal of solvent to obtain a concentrated extract. This method ensured efficient extraction of desired compounds while minimizing thermal degradation. The rotavap operates by creating a vacuum inside a rotating flask containing the solvent-extracted filtrate. This vacuum lowered the boiling point of the solvent, typically ethanol in this case, causing it to evaporate more efficiently at lower temperatures. The rotating flask ensured a larger surface area for evaporation, speeding up the process. The evaporated solvent was then condensed and collected separately, leaving behind a concentrated extract of the desired plant components in the flask. This method allowed for the extraction of sensitive compounds while minimizing heat exposure, thereby preserving their bioactivity for subsequent analysis and characterization in the research study. The researchers monitored the entire evaporation process to stop the machine either when the solvent began boiling or had completely evaporated.

The concentrations used for the extract in this study were 25%, 50%, and 75%. These concentrations were prepared by mixing a calculated amount of the concentrated extract with an appropriate volume of distilled water, ensuring that the total volume for each sample was 1000 µL. Their preparations were as follows:

- For a 25% concentration, 250 µL of the concentrated extract was mixed with 750 µL of distilled water to make a total volume of 1000 µL.
- For a 50% concentration, 500 µL of the concentrated extract was mixed with 500 µL of distilled water to make a total volume of 1000 µL.
- For a 75% concentration, 750 µL of the concentrated extract was mixed with 250 µL of distilled water to make a total volume of 1000 µL.

The varying concentrations of plant parts were immersed in blank sterile 6mm antibiotic discs, with 20 µL applied to each disc. Subsequently, the discs were left to air dry in a biosafety cabinet at the Microbiology Laboratory of the College of Medical Technology, University of Cebu - Banilad. This preparation method ensured that the discs were ready for immediate use following streaking of bacteria on petri dishes for the disk diffusion method. Two pathogenic bacterial species were used in this study: Staphylococcus aureus, a gram-positive bacterium, and Escherichia coli, a gram-negative bacterium. These bacterial species were obtained from the Microbiology Department of the University of Cebu Medical Center.

The preparation of Tryptone Soy Agar (TSA) and Mueller Hinton Agar (MHA) involved following established protocols using products purchased from Yana Chemodities, Inc. TSA was prepared by dissolving 40 grams of agar powder in 1000 mL of distilled water, while MHA was prepared using 38 grams of agar powder per 1000 mL of distilled water. The preparations of these agars were followed upon manufacturers instructions. Both agar solutions were mixed first in room temperature distilled water inside a 1000mL erlenmeyer flask to dissolve completely without clumps and were subsequently heated on a hot plate and stopped when boiling ensues. Afterwards, the erlenmeyer flasks were covered with cotton and aluminum foil for them to autoclaved at 121 °C for 15 minutes. After sterilization, the agar was poured into sterile petri dishes and allowed to solidify under aseptic conditions. Both types of agar were then stored at appropriate temperatures until used in bacterial culture and antimicrobial testing procedures as part of the research study.

The preparation of subcultures for Staphylococcus aureus and Escherichia coli involved obtaining bacterial strains from the University of Cebu Medical Center - UCMed. Each bacterial strain was subcultured onto Tryptone Soy Agar (TSA) plates using an isolation streak method. This method ensured the growth of pure bacterial colonies by streaking the bacteria in a manner that isolated individual cells to form distinct colonies on the agar surface. The subcultured plates were then incubated at 37°C for 24 hours to allow bacterial growth. The preparation of bacterial suspension involved using subcultured bacterial species colonies grown on Tryptone Soy Agar (TSA). Each colony from both bacteria was carefully harvested from the agar plate using a sterile loop and transferred into separate tubes containing normal saline solution (NSS). The colonies were thoroughly mixed in NSS, which served as the liquid medium for suspending, and then adjusted to match the turbidity equivalent of a 0.5 McFarland standard.

The disc diffusion test was performed using the Kirby-Bauer method. A sterile, nontoxic cotton swab was dipped into the bacterial suspension. The excess fluid was then expressed by pressing and rotating the swab against the side of the tube above its fluid level. The swab was used to streak evenly over the entire surface of the Mueller-Hinton agar plate, ensuring uniform and confluent inoculation. Two additional streaks were performed, each time turning the plate by approximately 60°. A final sweep against the agar's rim using the same cotton swab was done to ensure detection of any bacteria capable of growing on the edge. Afterward, the plates were left to dry for ten minutes. Using sterile forceps, the antibiotic discs and the plant extract-immersed discs were aseptically placed on the surface of each plate. Each plate contained discs of the same plant part but with varying concentrations, along with a negative control (no antibiotic) and positive controls, including oxacillin for Staphylococcus aureus and levofloxacin for Escherichia coli. Every disc was pressed down to ensure full contact with the agar surface. To avoid overlapping zones, the discs were spaced at least 20 mm apart and no closer than 15 mm from the plate's edge. The plates were turned upside down to prevent moisture from building up on the lid and falling onto the agar surface, where it could cause distinct colonies to clump together. The plates were placed in an incubator at 37°C for 24 hours. Results were then obtained after 24 hours.

Treatment of Data

The diameter of the zone of inhibition is expressed as mean ± standard deviation. The data is analyzed using One Way Analysis of Variance (ANOVA), and Least Significant Difference (LSD). P value <0.05 is considered as significant and mean values were computed and compared using Statistical Package for Social Sciences (SPSS) software version 25. One Way ANOVA was used to determine any significant difference between the Zone of Inhibition and Concentrations of Plant Extract. Least significant difference was then performed as a pairwise comparison between the means to identify which pair of means differ significantly from each other.

FINDINGS

Plant-based extracts have received great interest in fighting microbial infection because of their potential as natural antimicrobial agents. Among them, *Averrhoa bilimbi*, locally called kamias, has been sought after for its potential antibacterial properties. This study aimed at evaluating the antimicrobial activity of various parts of A. bilimbi against two common pathogens: *Staphylococcus aureus* and *Escherichia coli*. Using the disc diffusion assay, zones of inhibition against each test organism were measured and the analysis was used to determine the efficacy of varied concentrations of plant extracts. The zones of inhibition observed in the disc diffusion assay are shown in Tables 1 and 2 for *Staphylococcus aureus* and *Escherichia coli*, respectively. The collected data from the observations were analyzed using statistical methods: One Way Analysis of Variance (ANOVA), and Least Significant Difference (LSD). The antimicrobial efficacy of the varying concentrations of the extracts made from the different plant parts was compared and contrasted using ANOVA utilizing Statistical Package for Social Sciences (SPSS) software version 25 in an effort to find correlations between the concentration of bioactive chemicals and the antimicrobial activity they produced.

Table 1. The mean zone of inhibition of *Averrhoa bilimbi* plant part extracts against gram-positive bacterium *Staphylococcus aureus*

Concentration of Plant Extract	Fruit Zone of Inhibition (mm)	Root Zone of Inhibition (mm)	Stem Zone of Inhibition (mm)	Branch Zone of Inhibition (mm)
Positive Control	20.000	20.000	20.000	20.000
Negative Control	0.000	0.000	0.000	0.000
75%	9.000	12.500	8.000	8.000
50%	8.500	11.000	8.000	7.250
25%	7.000	9.500	3.500	0.000

The root extract had the highest zone of inhibition compared to the other plant part extracts with a ZOI of 12.500 mm at 75% concentration and 9.500 mm at 25% concentration. Moreover, the fruit extract of Averrhoa bilimbi exhibited the maximum ZOI of 9.000 mm at 75% concentration against *Staphylococcus aureus* and a minimum ZOI of 7.000 mm at 25% concentration. Both stem and branch extracts demonstrated a maximum zone of inhibition of 8.000 mm at 75% concentration, where the only difference is that only the stem extract exhibited a ZOI of 3.500 mm at 25% concentration whereas the branch extract yielded no ZOI, which is shown in Table 2.1.

The most notable result obtained was shown using 75% concentration of root extract. It exhibited the largest inhibition zone of 12.500 mm followed by fruit (9.000 mm), stem (8.000 mm) and branch (8.000 mm). These results indicated that the 75% root extract of *A. bilimbi* has the highest potential against *S. aureus* among the tested plant parts at the given concentrations.

These data highlighted the significance of the concentration in maximizing the antimicrobial efficacy of *A. bilimbi* extracts. Particularly, it emphasized the root extract's greater efficacy at higher concentration, indicating its prominent role in inhibiting bacterial growth.

Table 2. The mean zone of inhibition of *Averrhoa bilimbi* plant part extracts against gram-negative bacterium *Escherichia coli*

Concentration of Plant Extract	Fruit Zone of Inhibition (mm)	Root Zone of Inhibition (mm)	Stem Zone of Inhibition (mm)	Branch Zone of Inhibition (mm)
Positive Control	39.500	39.500	39.500	39.500
Negative Control	0.000	0.000	0.000	0.000
75%	0.000	0.000	0.000	0.000
50%	0.000	0.000	0.000	0.000
25%	0.000	0.000	0.000	0.000

The data indicated that the positive control consistently showed a 3.950 mm inhibition zone, confirming the antibacterial agent's effectiveness, while the negative control showed no inhibition, validating the absence of external contamination in the experimental setup (Table 2). For the ethanolic extracts of *Averrhoa bilimbi*, across all tested concentrations (75%, 50%, and 25%), no inhibition zones were observed for any plant part (fruit, root, stem, and branch). This suggested that under the experimental conditions employed, the ethanolic extracts of *A. bilimbi* did not demonstrate measurable antibacterial

activity against *Escherichia coli*. These findings indicated that *E. coli* exhibited resistance to the ethanolic extracts of *A. bilimbi* at the concentrations tested.

The significance value of fruit extract of *A. bilimbi* was 0.002 while root, stem and branch against S. aureus were 0.000, using One Way ANOVA where $p<0.050$ was considered significant. This implied that fruit, root, stem, and branch extract of A. bilimbi at various concentrations had an effect on the growth of S. aureus. On the other hand, ethanolic extract of *A. bilimbi* had no significant effect against *E. coli* as it did not exhibit any inhibition zone. Furthermore, the One Way ANOVA test only showed any significant influence of various plant extract concentrations with *S. aureus* and *E. coli* but did not show which plant part exhibited any significant difference at varied concentrations against the bacterial growth (Table 2.3.). Therefore, a Least Significant Difference (LSD) test was performed on the fruit, root, stem and branch extracts, as illustrated in Tables 2.3. to 2.6.

Least Significant Difference

Tables 3 to 6 presented the Least Significant Difference test results for *Averrhoa bilimbi* fruit, root, stem, and branch extracts against *Staphylococcus aureus*. The LSD test was conducted following One Way ANOVA to identify specific concentrations where significant differences in bacterial inhibition were observed.

Table 3. LSD test results of *Averrhoa bilimbi* fruit extract against *S. aureus*.

Concentration	K (+)	K (-)	75%	50%	25%
K (+)	-	0.000	0.004	0.004	0.001
K (-)	0.000	-	0.010	0.013	0.178
75%	0.004	0.010	-	0.832	0.057
50%	0.004	0.013	0.832	-	0.076
25%	0.001	0.178	0.057	0.076	-

The following table showed the results of the LSD test of *A. bilimbi* fruit extract against Staphylococcus aureus. There were significant differences noted primarily at 75% concentration compared with other concentrations and controls. Specifically, at the concentration of 75%, there was a significant difference with the positive control having a $p = 0.004$. At 50% concentration, there were significant differences with both the positive ($p = 0.004$) and negative ($p = 0.013$) controls, and at 25% concentration, only the positive control was significantly different with a p-value of 0.001. The findings indicated that the fruit extract, especially at higher concentrations, significantly inhibited *S. aureus*.

Table 4. LSD test result of *Averrhoa bilimbi* root extract against *S. aureus*

Concentration	K (+)	K (-)	75%	50%	25%
K (+)	-	0.000	0.000	0.000	0.000
K (-)	0.000	-	0.000	0.000	0.000
75%	0.000	0.000	-	0.020	0.001
50%	0.000	0.000	0.020	-	0.020
25%	0.000	0.000	0.001	0.020	-

The following table showed LSD results of A. bilimbi root extract against Staphylococcus aureus. Patterns observed in the root extracts showed significant differences at varied concentrations compared to the control and other concentration extracts. The root extract indicated that the concentrations of 75%, 50% and 25% with each other, and positive and negative controls, showed significant differences (all $p = 0.000$). Additionally, there were significant differences between the 75% and 50% concentrations ($p = 0.020$) and between the 75% and 25% concentrations ($p = 0.001$). The results can be said to have established that the root extract exhibited progressive consistency in controlling S. aureus growth at all the tested concentrations.

Table 5. LSD test result of *Averrhoa bilimbi* stem extract against *S. aureus*.

Concentration	K (+)	K (-)	75%	50%	25%
K (+)	-	0.000	0.003	0.003	0.001
K (-)	0.000	-	0.015	0.015	0.175
75%	0.003	0.015	-	1.000	0.098
50%	0.003	0.015	1.000	-	0.098
25%	0.001	0.175	0.098	0.098	-

The following table showed the results of LSD tests of A. bilimbi stem extract against *Staphylococcus aureus*. Stem extract concentrations of 75%, 50% with positive and negative control, and 25% with positive control shows significant difference. The concentration of 75% had no significant difference with 50% ($p = 1.000$) and 25% ($p = 0.098$), implying that it had no significant difference in providing antimicrobial properties against *S. aureus*. The stem extract showed significant differences at 75% and 50% concentrations against both the positive and negative controls with $p = 0.003$ and $p = 0.015$, respectively. At a concentration of 25%, there was significant difference with the positive control, $p= 0.001$. The results indicated that the extracts from the stem had no significant antimicrobial activity, particularly at any concentrations.

Table 6. LSD test result of *Averrhoa bilimbi* branch extract against *S. aureus*.

Concentration	K (+)	K (-)	75%	50%	25%
K (+)	-	0.000	0.000	0.000	0.000
K (-)	0.000	-	0.000	0.000	1.000
75%	0.000	0.000	-	0.005	0.000
50%	0.000	0.000	0.005	-	0.000
25%	0.000	1.000	0.000	0.000	-

This table showed the LSD results for the branch extract of *A. bilimbi* against *Staphylococcus aureus*. There were significant differences noted with the three concentrations (75%, 50%, and 25%) of the branch extract when compared to both the positive and negative controls ($p = 0.000$), except the 25% compared with the negative control ($p = 1.000$). The 75% concentration also showed significant differences with the 50% ($p = 0.005$) and 25% ($p = 0.000$) concentrations. These results highlighted the branch extract's effectiveness in inhibiting *S. aureus*, particularly at higher concentrations.

Overall, these findings showed the varying potency of *Averrhoa bilimbi* extracts against *Staphylococcus aureus*, emphasizing their effectiveness at higher concentrations. The LSD test revealed specific concentration levels at which significant antibacterial activity was observed, highlighting the potential of these extracts in contributing to the understanding of natural antibacterial agents.

CONCLUSIONS

The plant *Averrhoa bilimbi* cannot inhibit the growth of gram positive and negative strains of bacteria. The results of the experimental study conducted shows that *Escherichia coli* and *Staphylococcus aureus* are both resistant towards the different plant extract concentrations which was reflected by their little to no zone of inhibition and are not effective. The study's findings indicate significant differences in the mean Zone of Inhibition (ZOI) among Averrhoa bilimbi fruit, root, stem, and branch extracts compared to positive and negative controls against.

Staphylococcus aureus and *Escherichia coli*. This concludes the rejection of the second null hypothesis which supports the acceptance of the alternative hypothesis, affirming the distinct antimicrobial effects of *Averrhoa bilimbi* extracts on both bacterial strains. Therefore, we can conclude that the *Averrhoa bilimbi's* capability to inhibit the growth of bacteria is not as efficient as synthetic antibiotics.

RECOMMENDATION

After thorough assessment and considering the foregoing findings and conclusion of the study the following recommendations are presented:

1. Investigate the potential synergistic effects of *Averrhoa bilimbi* extracts with conventional antibiotics to enhance antibacterial activity
    1.1. This could involve testing different combinations of extracts and antibiotics to determine if they work together to improve efficacy against resistant bacterial strains.
2. Investigate the effects of using *Averrhoa bilimbi* extracts at full concentration (100%)
    2.1. Utilizing 100% concentration can provide a clearer understanding of the maximum inhibitory potential of these extracts against bacterial pathogens.
3. The quantity of samples of the different plant parts of *Averrhoa bilimbi*.
    3.1. Each plant part should have enough and equal amount of samples. The amount of samples can affect the results of the experiment due to its variation. The results would be more accurate if samples are increased in quantity.
4. Increased the number of trials in each plant part with its corresponding concentration.
    4.1. The number of trials determine the validity of the results and ensure that they do not happen in random occurrence. This also reduces the influence of random errors. Trials also determine the accuracy of the experiment in which we can consider its reliability.
5. Further research should focus on optimizing extraction methods to maximize the concentration and potency of antimicrobial compounds in *Averrhoa bilimbi* extracts.
    5.1. Different extraction solvents and techniques could be explored to enhance the extraction efficiency and bioactivity of these extracts
6. Explore potential non-antimicrobial applications of *Averrhoa bilimbi* extracts, such as anti-inflammatory or antioxidant properties, which could provide additional therapeutic benefits.
7. Determine the Minimum Inhibitory Concentration (MIC) of the antimicrobial properties of the plant extracts.

By addressing these recommendations, future research can build upon the current findings and further elucidate the potential of Averrhoa bilimbi extracts as valuable antimicrobial agents, potentially offering new solutions in the fight against antibiotic-resistant bacteria.

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INSTRUCTIONAL MANAGEMENT PRACTICES AMONG KINDERGARTEN TEACHERS IN REGION III: TOWARDS A PROPOSED ASSESSMENT TOOLS

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ABSTRACT

The study is designed to describe and analyze the instructional practices of kindergarten teachers in selected Central schools in Region III. One hundred seventy-five (175) Kindergarten teachers in Central Elementary schools per Division in Region III were the total respondents of the study. The data gathered from the respondents was through a set of questionnaires for the teachers. Findings revealed that teachers have strong points in Guidance Skills and Teaching Skills, average in Management Skills, and weak in Evaluation Skills. Teachers encountered serious problems in the misbehavior of pupils in the classroom, had serious problem in poor communication and comprehension skills, poor study habits of pupils was also considered a serious problem among kindergarten teachers, and disruptive pupils while lesson is going on were also a serious problem experienced by the teachers. It is recommended that teachers should undergo brainstorming with other kindergarten teachers within the district or province. Seminars focusing on instructional materials should be attended by the teachers and collaborate freely with parents to be partners in molding the children.

INTRODUCTION

The main aim of education is to produce human beings who are able to appreciate the benefits of education and contribute to the development of the community in different spheres of life be it political, social, economic or technological. Teaching is the process which always needs new and innovative principles, rules, techniques, methods and procedure in order to meet the required needs and desires of the learners. Like the technical and technological changes and developments at global level, the teaching also needs to change to meet the desired needs. A teacher has to tackle the challenges and move forward to the future.

Teachers should understand management of the classroom as well they play an important role in the teaching and learning process. Moreover, they since demanded to handle the activities in the classroom and make those effective and interesting. Instructional management helps the teachers to observe the development process of their students. How one manages the classroom is the primary determinant of how well your students learn.

Conversely, when students are successful and actively engaged in their work, they tend to be well behaved. Therefore, keep students involved in their work, have students understand what is expected of them, maximize time on task, prevent confusion or disruption, and run a work simulated but relaxed and pleasant classroom.

Instructional management practices of teachers play a vital role within the four walls of the classroom. This is developed individually. It should not be based on whims, biases or personal opinion only. This is because each pupil is unique in his own ways. Schools are the formal agencies of education where the future citizens are shaped and developed through the process of teaching and learning. Schools need to help all students to develop their potentials to the fullest level. This requires the effectiveness and commitment of the stockholders particularly teachers, school heads and the administrators.

To achieve these expected outcomes, there is a need to have well selected curriculum, improved instructional situations and professionally motivated and competent teachers. In line with this, there are

different variables that have their own contribution for its development. One of the most important is the teacher who needs effective instructional support. The relevant and quality education can be provided for the learners by engaging them to well-trained and professionally developed teachers at all levels of education. It is meaningless to build schools and distribute educational materials without effective and efficient human power that can transmit the educational content to learners.

Instructional management practices refer to the way teachers practice or behave in their role in teaching measured by such aspects as teaching techniques, classroom management, methodology and evaluation techniques and relating to pupils. Schools must improve their basic functions of teaching and learning process that aims at helping and empowering all students to raise their broad outcomes through instructional improvement.

In view of this concept, it is essential that kindergarten children be immersed with activities that give them the opportunity to use their senses, like in games, and in plays. These activities should help the children acquire skills and competencies that are appropriate for their holistic development as emergent learners and prepare the children for formal school (DepEd K to 12 Curriculum Guide for Kindergarten, 2012). It is in this sense a review of various curriculum development models must be done to provide valuable insights and ideas on the development of a model for developing curriculum standards for pre-school education. The curriculum should be supported with different instructional materials that help the teachers to teach with ease and the learners to learn without stress.

Teachers develop and implement a range of instructional strategies that address pupils' needs, abilities and learning styles and are based on these opportunities and instructions. Teachers also continually assess pupils' achievements and progress using a variety of appropriate strategies. All teachers use assessment to drive pupil's learning forward. It is a concrete way for teachers to communicate to parents their child's strengths and areas for improvement.

It is along with these facts that this research was conducted. The researcher was motivated to conduct this study with the end in view of suggesting some reforms, innovations, specifically the instructional management practices among kindergarten teachers towards a proposed action plan in order to make teachers more effective in the delivery of quality education.

STATEMENT OF THE PROBLEM

The study is designed to describe and analyze the instructional practices of Kindergarten teachers in selected schools in Region III.

More specifically, it sought the following:

1. How is the Instructional Management Practices of the kindergarten teachers described in terms of:
   1.1 Teaching Skills;
   1.2 Guidance Skills;
   1.3 Management Skills; and
   1.4 Evaluation Skills?

2. What are the Strengths and Weaknesses of the kindergarten teachers based on their Instructional Management Practices?

3. What are the challenges encountered by the Kindergarten Teachers in their Instructional Management Practices?

4. What action plan could be proposed to address the challenges encountered by the teachers?

5. What is the Implication of the study to Educational Management?

METHODOLOGY

Methods of Study and Sources of Data

This chapter presents a description of the research design, the respondents of the study, methods of gathering data .data gathering procedure and research instruments used for data collection, ethical consideration and statistical treatment of the data that were utilized.

Research Design

The researcher utilized the descriptive method of research via questionnaires. According to Gay (1984), descriptive method involves the collection of data in order to test hypothesis or to answer questions concerning the current state of the subject of the study. This type of research determines the reports the way things are. It has no control over what is and it can only measure what already exists.

Respondents of the Study

The respondents of this study were the one hundred seventy-five (175) Kindergarten teachers. Twenty-five (25) each for the seven (7) provinces in Region III which are Aurora, Bataan, Bulacan, Nueva Ecija, Pampanga, Tarlac, and Zambales.

Provinces	Number of Kindergarten Teachers	Respondents
Aurora		25
Bataan		25
Bulacan		25
Nueva Ecija		25
Pampanga		25
Tarlac		25
Zambales		25

The selection was done by simple random sampling with the guidance of the head of the school.

Methods of Gathering Data

The researcher used the indirect or questionnaire method in gathering data for this study. The set of questionnaires were adapted from the study of Lozano (2009). The researcher was prompted to seek the assistance of the specialists to validate the questionnaire. The questionnaires were distributed for the dry run to the Division of Tarlac Province after which treated statistically to test the validity. After confirming the Validity, the reliability test was done using Cronbach's Alpha for Teachers Skills (0.987), Guidance Skills (0.989), for Management Skills (0.980), and for Evaluation Skills (0.985) were all exceeded the limits (0.700) which means that the questionnaire was reliable.

Data Gathering Procedure

The researcher sought permission from the Schools Division Superintendent in every Division of Region III to conduct the study "Instructional Management Practices among Kindergarten Teachers in Region III: Towards a Proposed Assessment Tools."

Upon approval of the request, letters were prepared to each school head of Schools in Region III with their teacher respondents to ask their participation and cooperation in the study.

The data gathered from the respondents was through a set of questionnaires for the teachers. After two weeks, the set of questionnaires were retrieved from the respondents.

Instruments

The data gathered were quantitatively described and analyzed through the following instruments:

1. Likert Scaling Technique

Index Scale	Limit of the Index	Verbal Description
5	4.51-5.00	Very Highly Effective
4	3.51-4.50	Highly Effective
3	2.51-3.50	Effective
2	1.51-2.50	Barely Effective
1	1.00-1.50	Not Effective

2. Using the number code, the respondents were asked to rate each statement to indicate how it was applied to them.

The responses with number code were as follows:

5 – Very highly effective / Excellent
4 – Highly effective / Very good
3 – Effective / Good
2 – Barely effective / Fair
1 – Not effective / Poor

Ethical Considerations

All research involving human participants should be conducted by the ethical principles in the General Ethical Guidelines for Health Research (Philippine Health Research Ethics Board, 2011). This study underwent a comprehensive ethics review by the Tarlac State University – Research Review Committee (TSU- RERC).

Likewise, the respondents were informed of a non- monetary consideration or whatsoever in connection with the undertaking. Respondents were assured of physical and mental infliction-free upon participation. The researcher assured that all data collected were taken with the outmost confidentiality.

Statistical Treatment

The following statistical measures were employed in order to interpret the responses in answer to specific problems.

To determine the effectiveness of the instructional management practices of teachers in the different dimensions as stated in the problem of the study, the problems and the suggestions of the teachers among their pupils to improve teacher-pupils relationship, the responses gathered were evaluated using weighted mean.

The responses with number code were tallied and set into table for interpretation and analysis to determine the instructional management problems encountered by the kindergarten teachers.

FINDINGS

Instructional Management Practices

Instructional management helps the teachers to observe the development process of their students. How one manages the classroom is the primary determinant of how well your students learn. Conversely, when students are successful and actively engaged in their work, they tend to be well behaved. Therefore, keep students involved in their work, have students understand what is expected of them, maximize time on task, prevent confusion or disruption, and run a work simulated but relaxed and pleasant classroom (Rahmawati, 2017).

In this study, instructional management practices of teachers refer to teaching skills, guidance skills, management skills, and evaluation skills.

Table 1. Summary Table of Instructional Management Practices

Dimensions	Grand Mean	Descriptive Rating
Teaching Skills	4.36	Highly Effective
Guidance Skills	4.38	Highly Effective
Management Skills	4.34	Highly Effective
Evaluation Skills	4.29	Highly Effective
Composite Mean	**4.34**	**Highly Effective**

Findings revealed that teachers were highly effective (4.47) in providing varied learning experiences for the development of communication, work, interpretative and other basic skills involved in the learning tasks, highly effective (4.42) in helping pupils develop self-discipline in and through the learning process, highly effective in preparing adequately for the day's learning activities (4.44), and also highly effective in making a continuing assessment of pupils' achievement (4.32).

Teachers have strong points in Guidance Skills (4.38) and Teaching Skills (4.36), average in Management Skills (4.34), and weak in Evaluation Skills (4.29).

Instructional Management Problems

A well-managed classroom provides an environment in which teaching and learning can flourish. But a well-managed classroom does not just appear out of nowhere. It takes a good deal of effort to create and the person who is most responsible for creating it is the teacher. This section will provide the extent of the problems encountered by the kindergarten teachers in instructional management.

Instructional Management Challenges Encountered

Instructional Problems	Mean	Descriptive Rating
Misbehavior in the classroom.	3.96	Serious
Poor communication and comprehension skills.	3.93	Serious
Poor study habits.	3.87	Serious
Disruptive pupils while lesson is going on.	3.86	Serious
Lack of interest to learn.	3.82	Serious
Neglect of pupils on assignment or homework.	3.78	Serious
Dependent on teachers' instructions.	3.77	Serious
Moving back and forth around the classroom while instructions/ recitations are going.	3.72	Serious
Personal physical health.	3.63	Serious
Grand Mean	**3.82**	**Serious**

Teachers encountered serious problems in the misbehavior of pupils in the classroom (3.96), had serious problem in poor communication and comprehension skills (3.93), poor study habits (3.87) of pupils were also considered a serious problem among kindergarten teachers, and disruptive pupils while lesson is going on (3.86) were also a serious problem experienced by the teachers.

Proposed Action Plan

Developing an action plan can help educators turn their visions into reality, and increase efficiency and accountability within an organization. An action plan describes the way institution will meet its objectives through detailed action steps that describe how and when these steps will be taken. This section provides a guide for developing and utilizing the proposed action plan.

The action plan presented on the next page displayed the essential action to be executed by the researcher together with the administrators. It focused on the resource requirements that served as a proof that the activities were done successfully and to address the problems encountered by the kindergarten teachers.

CONCLUSIONS

Based on the results of the study, the researcher concludes that:

1. Teachers were highly effective in highly effective in providing varied learning experiences for the development of communication, work, interpretative and other basic skills involved in the learning tasks, highly effective in helping pupils develop self-discipline in and through the learning process, highly effective in preparing adequately for the day's learning activities, and also highly effective in making a continuing assessment of pupils achievement.
2. Teachers were strong in Guidance skills and teaching skills, average in management skills, and weak in evaluation skills.
3. Teachers encountered serious problems in the misbehavior of pupils in the classroom, poor communication and comprehension skills, poor study habits, and disruptive pupils while lesson is going on.

RECOMMENDATIONS

The following recommendations are based on the findings of the study:

1. Teachers should attend seminar workshop and training in research writing. Should undergo brainstorming with other kindergarten teachers within the district or province. Teachers should attend seminars focusing on instructional materials. Teachers should collaborate freely with parents to be partners in molding the children. Teachers should attend seminars regarding strategies in teaching

and learning process dealing with kindergarten. And teachers should check and balance test administration and assessment

2. Teachers should attend seminar workshop and trainings on handling pupil's misbehavior, Team up with parents and deal with their child's study habits, attend seminar dealing with poor study habits of pupils.
3. For future researchers, it is highly recommended to further study a relationship of the instructional management of teachers and the parental involvement in relationship to pupils' performance.

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