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UNIFFIED INTERNATIONAL JOURNAL OF MULTIDISCIPLINARY RESEARCH (UIMRJ)

Rationale

The UNIFFIED International Journal of Multidisciplinary Research (UIMRJ) is a quarterly, peer-reviewed journal published in both print and online formats. It provides an international platform for the publication of original scholarly research that advances knowledge across diverse academic disciplines. Authors grant full publication authority to the journal upon acceptance of their work.
UIMRJ was established to sustain and extend scholarly engagement generated through UNIFFIED's academic initiatives by offering a reliable venue for the dissemination, validation, and preservation of high-quality research. The journal promotes interdisciplinary dialogue and supports research as a central driver of innovation, educational improvement, and evidence-based practice.

The journal publishes research across the following academic strands: Accountancy, Business and Management (ABM); Humanities and Social Sciences (HUMSS); Science, Technology, Engineering and Mathematics (STEM); Technology Education (TE); and General Academics (GA). It welcomes contributions from academicians, educators, researchers, and professionals worldwide who are committed to advancing educational standards and professional practice.

Through UIMRJ, UNIFFIED advances its mission to lead, serve, and innovate by fostering scholarly collaboration, encouraging transformative research, and responding to the evolving demands of education and society.

Cover Image

Designed by Dr. Rosalinda S. Bajolo, the cover conveys academic leadership, innovation, and global collaboration through a cool blue color palette that reflects trust, rigor, and intellectual depth. The prominent placement of the journal title establishes scholarly identity and credibility. Silhouetted figures, together with multidisciplinary academic symbols, emphasize research dissemination, knowledge sharing, and interdisciplinary scholarship.

EDITORIAL POLICY – INTERNATIONAL PEER-REVIEWED JOURNAL

Publication Ethics and Malpractice

1. The UNIFFIED International Journal of Multidisciplinary Research (UIMRJ) is committed to upholding the highest standards of publication ethics and takes all necessary measures to prevent publication malpractice.
2. Authors submitting manuscripts attest that their work is original and has not been plagiarized, in whole or in part, from other sources.
3. Authors must disclose any actual or potential conflicts of interest. Likewise, the journal ensures an objective and fair double-blind peer-review process, preventing conflicts of interest among editors, reviewers, and authors.
4. Any ethical concerns or violations should be reported directly to the Editors-in-Chief, who are committed to providing timely and appropriate resolutions.
5. Editors and reviewers are responsible for providing constructive, objective, and timely evaluations based on scholarly contribution, analytical rigor, and clarity of presentation.

THE PEER-REVIEW SYSTEM

Definition

Peer review is the evaluation of scholarly work by experts in the relevant field to ensure that manuscripts meet disciplinary standards, contribute original knowledge, and present well-supported arguments. This process strengthens research quality by identifying limitations and recommending improvements. For publication, submissions must demonstrate both novelty and scholarly significance.

Type of Review

UIMRJ employs a **double-blind peer-review process**, in which the identities of both authors and reviewers remain confidential.

Recruitment of Reviewers

The Editorial Board selects reviewers with demonstrated research expertise, evidenced by peer-reviewed publications, academic credentials, and prior reviewing experience. Authors may suggest potential reviewers, subject to Editorial Board approval. Reviewers must disclose any conflicts of interest and are not selected from the author's close associates. Reviewer identities remain confidential except in exceptional circumstances.

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Each manuscript is evaluated by **two to three independent reviewers**, typically including a subject-matter expert and a research or statistics expert. Reviewers provide written evaluations and recommendations, which are assessed by the Editorial Board before editorial decisions and feedback are communicated to the author(s).

Criteria for Acceptance or Rejection

A manuscript is accepted when it:

- is endorsed by at least **two reviewers**;
- substantially complies with reviewers' recommendations;
- adheres to ethical standards for studies involving human or animal subjects; and
- achieves a minimum of **80% originality** in plagiarism screening.

Editorial decisions include:

✓ Unconditional acceptance
✓ Acceptance with minor or major revisions
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In cases of substantially conflicting reviews, additional reviewers may be consulted.

Comments

The journal welcomes scholarly comments on previously published articles. Accepted comments may be accompanied by a response from the original author. All editorial and peer-review standards apply.

Technology-Based Quality Assurance

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Authors are encouraged to use the **Flesch-Kincaid Reading Ease Test** and the **Gunning Fog Index** to ensure clarity, coherence, and accessibility of their manuscripts.

Plagiarism Detection

Manuscripts must achieve at least 95% originality based on licensed plagiarism-detection software.

Citation Format

Manuscripts should follow APA, Chicago Manual of Style, or Council of Science Editors citation formats, as appropriate.

Word Count and Language Quality

- Abstract: ~250 words
- Full text: 4,000–5,000 words
- Grammarly score: minimum 90%

GUIDE FOR AUTHORS

Manuscript Preparation

Manuscripts should follow standard IMRAD structure and be typed double-spaced, using Segoe UI, 12-point font, with 2.5-cm margins. Tables, figures, and references must be properly formatted and consecutively numbered. Only SI or metric units should be used.

Tables and Figures

Figures should be clear, high-quality, and legible after reduction. Acceptable formats include JPEG or PNG. Titles and captions must be concise and self-explanatory.

Submission of Manuscripts

Manuscripts must not be under consideration elsewhere and should be submitted in Microsoft Word format via email to the Editor-in-Chief. Separate files are required for:
(a) title page with author details;
(b) anonymized manuscript; and
(c) supplementary materials.

Revisions must be submitted within two weeks of the decision letter.

Further information is available at research.uniffied.org and www.uniffied.org.

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MESSAGE FROM THE EDITOR-IN-CHIEF

UNIFFIED has always stood as a beacon of unity, leadership, and innovation. From its humble beginnings, the organization has grown into a dynamic and expanding network of educators and professionals committed to shaping the future of education and scholarship. As we move deeper into the era of artificial intelligence and rapid technological advancement, we are reminded that progress is never achieved by standing still, but by our collective ability to adapt, transform, and lead. Education, much like our organization, must continually reinvent itself to meet the evolving demands of a rapidly changing world.

As we present the Second Issue of the UNIFFIED International Multidisciplinary Research Journal (UIMRJ) for December 2025, I extend my heartfelt appreciation to our authors, reviewers, editors, and readers whose shared commitment continues to strengthen the culture of research and scholarly excellence within the UNIFFIED community and beyond.

This issue reflects UNIFFIED's enduring mission to provide a credible, inclusive, and rigorous platform for the dissemination of original and impactful research across disciplines. The studies featured in this volume represent diverse perspectives, methodologies, and contexts, yet they are unified by a common purpose—to advance knowledge, inform practice, and contribute meaningfully to the evolving landscape of education, research, and professional engagement.

As Editor-in-Chief and Co-Founder of the United Federation of Fil-Am Educators (UNIFFIED), I take pride in witnessing the continued growth of UIMRJ as a scholarly space that promotes interdisciplinary dialogue, critical inquiry, and evidence-based innovation. Beyond serving as a repository of research outputs, the journal functions as a vital bridge—connecting educators, researchers, and professionals across geographical, cultural, and disciplinary boundaries.

The successful publication of this second issue stands as a testament to the dedication of our contributors and the integrity of our peer-review process. I extend my sincere gratitude to our reviewers for their invaluable expertise and thoughtful evaluations, and to our editorial team for their unwavering commitment to upholding the highest standards of academic rigor, transparency, and ethical publishing.

As we move forward, UIMRJ remains steadfast in its commitment to nurturing research that responds to contemporary challenges and supports transformative change in education and society. We warmly invite scholars, educators, and practitioners to continue contributing to this growing body of knowledge and to partner with us in advancing research that truly leads, serves, and innovates.

Thank you for your continued trust, support, and shared dedication to scholarly excellence.

Dr. Ronie L. Mataquel
Editor-in-Chief, December 2025

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REFLECTING TO LEAD OR LEADING TO REFLECT: AN INSIGHT INTO THE RELATIONSHIP BETWEEN REFLECTIVE TEACHING AND TEACHER LEADERSHIP

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ABSTRACT:

While existing research has established the positive impact of teacher leadership on academic performance and school development, the relationship between reflective teaching and teacher leadership remains underexplored; thus, this study sought to bridge this gap by examining how reflective teaching practices influence teacher leadership, offering fresh insights into teachers' evolving roles in leading change, breaking boundaries, and transforming schools and universities. Grounded in UNICEF's Teacher and Education Policy, which advocates teachers' professional growth and empowerment to meet diverse student needs, the study employed a mixed-methods sequential explanatory design, with data collected through surveys and focus group discussions (FGDs). Guided by Larrivee's critical reflection framework, correlation and regression analyses revealed a significant relationship between reflective teaching and teacher leadership ($F = 5.165$; $p = 0.025$) at the 0.05 level of significance. Thematic analysis of FGD responses further revealed that teacher leaders commonly viewed themselves as "collaborative, passionate, and selfless," associated reflective teaching with "impact," and identified "heavy workload and vague policies" as key barriers to its practice. Based on these findings, the study presents key implications and recommendations for strengthening teacher leadership in schools and universities, emphasizing the importance of fostering an environment that supports and sustains a strong culture of reflective teaching.

KEYWORDS: *Teacher Leadership, Reflective Teaching, Pedagogical Reflection*

INTRODUCTION

In recent decades, educational institutions have increasingly sought to empower teachers as leaders. Wenner and Campbell (2017) define teacher leadership (TL) as the influence educators exert to drive change and innovation in schools and communities. TL goes beyond teaching, encompassing roles that inspire and improve educational environments. However, many educators have not embraced TL on a personal level (Cosenza 2015; Wenner & Campbell 2017). Studies suggest teachers lack intrinsic motivation to engage in leadership roles (Alegado & Edrada 2018; Araskal & Kilinc 2015) due to a lack of recognition of its value. There is thus a need to cultivate metacognitive awareness and reflective teaching (RT) practices to help educators appreciate and sustain TL ideals. York-Barr and Duke (2004) emphasize that TL enables teachers to influence peers, superiors, and stakeholders to enhance teaching and learning.

RT originates from Dewey's philosophy, which views teaching as a continuous process of reflection based on classroom experiences. Dewey (1938) suggests a five-step problem-solving model: suggesting solutions, questioning, hypothesizing, reasoning, and testing (Dymoke & Harrison 2008). RT involves systematic inquiry into teaching performance, refining teaching through evidence

collection, interpretation, and evaluation (Mathew & Peechattu 2017; Bawaneh et al. 2020). RT fosters TL by encouraging educators to self-regulate and adapt their practices.

However, RT adoption faces challenges, including low motivation, excessive workload, and inadequate training (Tajik & Ranjbar 2018; Baharuddin et al. 2020). Institutions have initiated strategies like teaching journals and peer observations to integrate RT into professional development (Sirutis & Massi 2014; Anyiendah 2014). Further research is needed to explore RT's role in TL and identify best practices.

RESEARCH QUESTIONS

Based on the identified gaps in theories, practices, and reviewed literature, this study intended to answer the following basic research questions.

RQ1: Is there a significant relationship between RT and TL?
RQ2: What are the recurring themes in the participants' concepts of RT and TL?
RQ3: What are the implications of RT and TL on teaching practice?

METHODOLOGY

Participants

Thirty educators with active teaching contracts in the academic year 2021 to 2022 were randomly selected to participate in this current study. They are from three educational levels in both public and private educational institutions in the Kingdom of Bahrain. Most of the educator participants are teaching at the primary educational level for eleven years or more and possess a bachelor's degree qualification (see Appendix A).

Research Design and Ethical Procedures

Under the mixed methods sequential explanatory design, the study included three stages of data processing, namely: preliminary protocols, primary data collection, and the primary data analytics. In the first stage, the participants who expressed in writing their prior, free, and informed consent to participate in the study were given alphanumeric codes (PTxx- primary teacher; STxx- secondary teacher; TTxx-tertiary teacher) as their unique identifiers to protect their personal information and to ensure their anonymity and privacy.

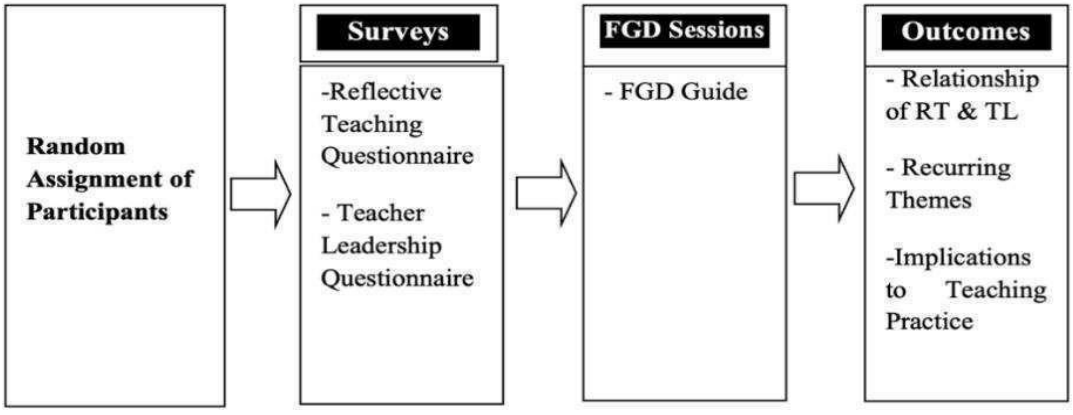

Figure 2:
Mixed Methods Sequential Explanatory Design Flow Chart

In the second stage, two electronic survey questionnaires were distributed to participants via email. They first evaluated the teachers' level of RT, and the second assessed their level of TL. Based on the survey findings, a series of online focus group discussions (FGD) were held with ten participants. These participants were grouped by their educational level: primary, secondary, and tertiary.

During the FGD, the facilitator outlined its purpose, and participants introduced themselves by stating their names and affiliations. They were then asked to share their opinions on TL and RT practices within their organizations. Each participant had an opportunity to speak and agree or disagree with others, while the facilitator provided probing insights. The session concluded with a summary and thanks to the participants. The attendance and retrieval rates for the surveys and FGD were both 100%.

In the third stage, primary data was processed, and correlation and regression tests were conducted to analyze the relationships between the variables. FGD recordings were transcribed, coded, and analyzed. Two recurring themes emerged: RT practices and TL's governing self-image. The FGD content was then classified into these themes.

To validate the reliability of the survey items, Cronbach alpha tests were performed, yielding a result of 0.72 for the RT questionnaire, indicating acceptable internal consistency.

DISCUSSION OF RESULTS

Levels of RT & TL and Their Significance of Relationship

The overall level of RT practices is 3.35, interpreted as “Exceptionally Average,” with pre-reflection practices being the lowest at 2.12 and pedagogical reflection practices the highest at 4.55. This indicates that the participant’s average RT is between 51 and 60 percent. The pedagogical reflection finding aligns with Ryken and Hamel’s (2016) observation that educators typically reflect on methods that impact their teaching. Such reflection encourages experimentation, risk-taking, and analysis of teaching effectiveness, enabling educators to connect new concepts to students’ prior knowledge and engage them more effectively.

On the other hand, the overall level of TL practices is 4.10, categorized as “Exceptionally High,” with all five indicators showing exceptionally high levels. This indicates a TL practice level between 71 and 80 percent. Although the participants’ overall TL is not directly linked to RT practices, there is a noted correlation between RT and TL at the pedagogical reflection level. This suggests that educators’ high level of pedagogical reflection enhances their TL practices (Sirutis & Massi, 2014).

Table 1: The Correlation Results of LEI, YTE, and LEA with RT and TL

Variables	*Reflective Teaching (RT)*	*Teacher Leadership (TL)*
Level of Educational Instruction (LEI)	0.47	0.25
Years of Teaching Experience (YTE)	0.08*	0.42
Level Educational Attainment (LEA)	0.G0	0.55
RT	—	0.025**

Note: **Correlation is significant at the 0.05 level (two-tailed). *Correlation is significant at the 0.10 level (two-tailed).

Table 1 presents the correlation analysis of the moderating variables with RT and TL practices. The results indicate that LEI, YTE, and LEA exceed the 0.05 significance level, suggesting that these moderating variables do not significantly impact TL. However, YTE is significantly correlated with RT at a 0.10 level of significance. This finding aligns with Ostaz (2011) and Orakci (2021), who reported that LEA has no significant influence on TL, except for YTE, which affects RT practices. This suggests that extended formal teaching experience enhances RT practices, reinforcing the importance of professional teaching experience in fostering reflective teaching. Without sufficient experience, reflection may become superficial and lead to ineffective conclusions.

Furthermore, to address RQ1, Table 1 reveals a significant relationship between RT and TL at the 0.05 level of significance. Since these two variables are correlated, the researchers further analyzed the effect of RT on TL. The findings suggest that educators' RT practices predict their TL, indicating that reflection directly influences teaching leadership. Higher levels of reflective practice led to stronger TL, as shown in Appendix C.

This finding supports the assertions of Brookfield (2017) and DeHart (2011), who emphasized that critical collaboration among educators enhances their ability to reflect collectively, thereby improving TL. Through collaborative reflection, educators can better respond to students' instructional needs and meet performance standards. This highlights the classroom as a crucial environment for cultivating reflective practitioners in a safe, open, and non-judgmental space. Such an environment fosters a learning culture where educators critically assess their practice, identify areas for improvement, and explore solutions.

Newell (2024) further explains that the social aspect of RT allows educators to analyze their teaching and leadership in a continuous cycle of professional learning. Reflective educators assess how their teaching methods impact student learning, evaluate instructional strategies, and explore alternative ways to present concepts effectively. Unlike isolated classrooms, RT practitioners engage in regular discussions, constructive disagreements, and proactive strategies to refine their practices, ultimately contributing to institutional goals (Brookfield, 2017).

Recurring Themes

To answer RQ2, Table 2 reveals the recurring themes in RT and TL practices as perceived and experienced by the participants. Accordingly, they identified a teacher leader as someone who possesses the traits of being "collaborative, passionate, and selfless" in terms of ensuring teaching and learning standards in meeting instructional goals. As participant TT-010 articulated, "A [sic] educator who takes the lead in developing instruction and professional competence to meet the instructional goals/standards." TT-005 concurred by saying "A committed educator who leads others passionately toward achieving a goal." These findings corroborate the roles of a teacher leader as defined by DeHart (2011) and Hamzah et al. (201G).

Table 2: Matrix of Themes and Frequency Distribution

Moderating Techniques	*Questions*	*Recurring Themes*	*Frequency Count (Ranking Order)*	*Anecdotal Description Techniques*
1.Top-of-mind Association	What's the first thing that comes to mind when you hear the words "teacher leader"?	Someone who meets professional standards and instructional goals	50%	Delivers effective, relevant, and engaging instructions
2. Constructing Images	Who do you consider a "teacher leader"? What does he/she look like? What kind of life does he/she live?	Collaborative	40%	Facilitates teamwork to achieve instructional and school goals
		Passionate	20%	Perform duties and responsibilities exceeding expectations
		Selfless	20%	Puts others' interest before themselves
3. Querying Meaning Context	Tell me about the most common situation in which you would reflect on your teaching practice.	After an assessment of learners' performance	G0%	Specifically, when learners do not meet the standards/objectives
	Describe to me a scenario in which you would exercise leadership in your teaching practice.	During an empowerment situation	40%	In an instance when there is an immediate need that can be fulfilled within their authority and/or means. However, a heavy workload and vague policies (cited by G0%) prevent educators from doing RT and TL practices
4. Projective Technique: Sentence Completion	Teachers who reflect and exercise leadership in their practice create . (one or two words) on their profession, students, schools, and communities.	Impact	50%	Social effects (immediate)
		Transformations	30%	Organizational effect (long-term)
		Competence	20%	Personal effect (direct)

This perception led this current study to probe specific instances in the teaching and learning process in which the participants were able to practice RT and TL. Most of them cited post-assessment scenarios especially when their learners' performance did not meet instructional objectives or standards. Other participants recognized this kind of scenario as an empowering situation where they could do something to bridge or fill in the learning gaps within their authority and capacity. PT-003 recalled that "I reflect usually if the students do not meet the objective/s of the lesson." TT-010 saw this situation as an opportunity saying, "When I see an immediate need that I can meet/deliver, I do something about it within my means." However, PT-002 lamented that "Heavy teaching schedules and unclear policies sometimes prevent me from doing those." This was concurred by PT-003 with a recommendation saying that "Teachers should be provided with sufficient time to be able to do those." These findings confirm the role and the challenges of RT in the learning process as observed by Wenner and Campbell (2017) and Bawaneh et al. (2020).

Finally, when inquired about what the participants thought about the influence of reflective teaching and teacher leadership in their practice, most of them mentioned "impact" as the word associated with the concept of RT-TL practices. TT-007 clarified that it referred to the "fulfillment of professional goals that leads to a positive impact on the organization." Raising a parallel point, ST-00G conjectured that RT-TL practices connote taking "a lead role in the social transformation of an organization." These findings confirm the observations of Nerlino (2020) on the dynamic roles of RT and TL in the learning process.

Implications to Practice

The third research question (RQ3) explored the implications of this study on RT-TL practices. Findings indicate that assessment outcomes, particularly when learners fail to meet performance standards, drive RT practices. Educators recognize opportunities for TL when they can address learning gaps within their authority. However, heavy workloads, limited time, and unclear instructional policies hinder RT-TL practices, which should not be restricted to assessments alone. These findings suggest the following implications.

First, a culture of learning must be cultivated. When RT-TL becomes ingrained in educators' professional identity, they are more likely to self-regulate their teaching. Organizational structures should support bottom-up decision-making, giving educators more autonomy, collaboration, and critical dialogue. Formal leaders should facilitate these discussions, ensuring that teachers feel empowered to challenge ideas and reflect on instructional practices (Anyiendah, 2014). Regular meetings—weekly, bi-monthly, or monthly—can provide structured opportunities for this dialogue.

Second, fostering a community of practitioners strengthens this culture. If organizations adjust their structures, teaching teams can network around shared challenges (Brookfield, 2017; Newell, 2024). Learning teams can collaborate on strategies to enhance engagement (e.g., gamified lessons) and improve performance (e.g., cooperative problem-solving). Peer mentorship can further support this process, where junior educators observe senior colleagues' classes and vice versa, exchanging best practices and diverse perspectives. Safe, welcoming spaces should be established, and designated time allotted for collaboration.

Third, a climate of innovation should sustain both the culture and community of practice. Instructional policies should empower educators to choose interventions that best bridge learning gaps.

Teachers should have autonomy to design authentic, varied assessments that accommodate different learning styles and reinforce soft skills (Cosenza, 2015; Araskal & Kilinc, 2015). Schools and universities can support this by integrating alternative assessments and allocating instructional time for interventions based on post-moderation evaluations.

RT-TL should be seen as an integral part of pedagogy rather than a reactive approach. It harnesses educators' reflective insights, which might otherwise go unutilized. For RT-TL practices to thrive, sustained administrative support—through policies and procedures—is essential. Schools and universities must create environments where educators can continuously refine their instructional competence, ultimately benefiting the teaching-learning process.

CONCLUSIONS

This study finds that RT practices predict educators' TL (RQ1). A weaker but notable correlation exists between YTE and RT practices. The results suggest a reciprocal relationship between pedagogical reflection and TL—teachers reflect to lead, and leading prompts further reflection, forming a cycle of reflective TL.

These findings align with the critical reflection framework. Higher levels of pedagogical reflection help educators assess their teaching's impact on students and take leadership actions based on broader sociological, economic, cultural, political, and historical contexts (RQ2).

However, this study is limited to an Arab cultural context. Future research should examine the RT-TL relationship in diverse settings, particularly its role in instructional transformation. These findings point to this direction for further inquiry.

Integrating reflective practice and TL into school and university systems fosters a learning culture, professional community, and climate of innovation (RQ3). When these elements are sustained, educators are more likely to reflect as a means of leadership. Teachers who engage in reflective practices continually refine their teaching, benefiting both themselves and their academic communities. Reflective TL thus serves as a key driver of educational growth and transformation.

RECOMMENDATIONS

[1]1 Allocate sufficient time for teachers to engage in reflective practices and incorporate reflections into lesson plans, report forms, journals, and diaries.

[1]2 Establish a program that encourages reflection and collaboration among teachers, organizing them into groups based on grade level and subject area to share and refine effective pedagogical approaches.

[1]3 Demonstrate and refine exemplary teaching leadership and practices to foster innovation, creativity, and engagement within the campus and community, promoting professional growth and empowering teachers to meet diverse student needs.

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Appendix

https://docs.google.com/document/d/18xr25re5FQv3p2RztzrJ_GZgS_21jDjH/edit

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EFFECTIVENESS OF TRANSACTIONAL STRATEGIES INSTRUCTION IN ENHANCING READING COMPREHENSION AMONG STUDENTS WITH SPECIFIC LEARNING DISABILITIES

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ABSTRACT:

Specific Learning Disabilities (SLD) are defined under the Individuals with Disabilities Education Act (IDEA) as a group of disorders that affect an individual's ability to read, listen, speak, reason, or perform mathematical calculations. According to IDEA, SLDs are characterized by a significant discrepancy between a student's academic achievement and their intellectual ability, which is measured through a comprehensive evaluation process (U.S. Department of Education, 2004). This legislation emphasizes the importance of early identification and intervention, allowing for tailored educational programs that meet the unique needs of each student. This study determined the applicability of Transactional Strategies Instruction (TSI) in enhancing reading comprehension among Students with Specific Learning Disabilities. The study involved 20 Grade 6 students of Bugarin Elementary School who exhibited reading comprehension disabilities. Employing an experimental research design, the study utilized percentage, mean, standard deviation, and t-tests to analyze data. Findings revealed that most participants were 12 years old, male, and performed at an instructional reading level prior to the intervention. After the implementation of TSI, participants achieved an independent reading level. The t-test results showed a significant difference between pre-test and post-test performances, confirming the efficacy of TSI in improving reading comprehension skill. Recommendations include integrating TSI into mainstream educational practices for Students with SLD and developing policies to support such instructional strategies.

KEYWORDS: *Transactional Strategies Instruction, reading comprehension, Specific Learning Disabilities, experimental design, Philippines.*

INTRODUCTION:

The journey toward cultivating proficient and confident readers has consistently been a pivotal concern in education, as literacy serves as the foundation for academic success and lifelong learning. However, reading comprehension remains a persistent challenge among learners across various educational settings, as identified by Applegate and Applegate (2019), who highlighted the disconnection between fluency and understanding in readers. To address this issue, the instructional approach known as Transactional Strategies Instruction (TSI) has emerged as a transformative pedagogical model.

It emphasizes interactive and strategic reading practices that enhance comprehension, critical thinking, and metacognition, as supported by Brown and Coy Ogan (2018) and Bergman and El-

Dinary (2018). This approach aligns with Rosenblatt's (2017) transactional theory, which underscores the dynamic interaction between the reader, the text, and the context during the reading process.

Effective comprehension instruction involves multiple layers of cognitive engagement, as articulated by Baker (2020) and Sinatra, Brown, and Reynolds (2020). The deliberate use of questioning strategies (Beck & McKeown, 2020), direct explanations (Roehler & Duffy, 2017), and reciprocal teaching (Marks et al., 2018; Takala, 2020) are evidence-based practices that promote a deeper understanding of texts.

These methods not only improve reading comprehension but also foster self-regulation and autonomous learning, as explored by Brown et al. (2019) and Julapho (2018). Moreover, the adaptability of these strategies to diverse learners, including English language learners (Gersten et al., 2017; Roit, 2020) and students with special learning needs (Graham & Bellert, 2005), further demonstrates their universal applicability and efficacy.

Despite advancements in comprehension research, disparities in literacy achievement persist globally, particularly among English Language Learners and students in low-resource environments (Cummins, 2020; Jepsen & de Alth, 2020). The No Child Left Behind Act of 2001 and subsequent literacy initiatives underscore the urgency to bridge these gaps, as evidenced by the findings of the National Reading Panel (2000) and the Organisation for Economic Co-operation and Development (2010).

Integrating transactional strategies within mainstream classrooms has shown promise in addressing these inequities by promoting critical literacy skills, as noted by Casteel, Isom, and Jordan (2019) and Pennell (2021). This paper aims to explore the evolving role of TSI and other comprehension strategies in fostering reading achievement, with a particular focus on their implementation across diverse contexts.

Drawing from foundational works such as the *Handbook of Language and Literacy* (Apel et al., 2017) and recent empirical studies (e.g., Pilonieta & Medina, 2019; Saovapa, 2021), this study examines the intersection of cognitive, linguistic, and sociocultural dimensions in reading instruction. By synthesizing insights from extensive research (Pressley, 2020; Wilkinson & Son, 2021), the discussion highlights innovative practices that address contemporary literacy challenges, including the integration of technology and multimodal resources (Julapho, 2018; Wichadee, 2021).

This paper underscores the imperative for educators and policymakers to adopt evidence-based, inclusive, and adaptive approaches to reading instruction. As highlighted by Wagner (2018), reimagining literacy education requires a concerted effort to redefine rigor and engage learners in meaningful, dialogic interactions with texts. Through the lens of TSI and related strategies, this study contributes to the ongoing discourse on equipping learners with the skills and confidence to navigate an increasingly complex and interconnected world.

Methods and Analysis:

This study employed an experimental design, which was deemed appropriate for addressing the objectives of the research. The experimental design facilitated the comparison of two groups: the control group and the experimental group. The experimental group was exposed to transactional strategies instruction (TSI), while the control group continued with the conventional method of

teaching. This design allowed for the systematic examination of the effects of TSI on learners' reading comprehension.

To ensure the reliability of the findings, the experimental procedure involved a pre-test and post-test for both groups. The pre-test was administered to establish a baseline of the students' reading comprehension levels before the intervention. The experimental group then underwent a series of instructional sessions utilizing TSI, which focused on collaborative and dialogic interactions, encouraging active engagement with the text to construct meaning. In contrast, the control group received instruction using traditional teaching strategies. After the intervention period, both groups were given the same post-test to measure any improvements in their reading comprehension. The difference in the pre-test and post-test scores within each group, as well as between the two groups, was analyzed to determine the effectiveness of the TSI approach.

Key variables were carefully controlled throughout the study to ensure that any observed differences in performance could be attributed solely to the independent variable—the use of TSI. Variables such as the instructional environment, duration of the intervention, and teacher qualifications were kept consistent for both groups. This strict control minimized extraneous factors and enhanced the validity of the results.

The researcher constructed and validated a teacher-made test to assess the students' reading comprehension. A thorough literature review and consultation with educational resources guided the test development process. Despite extensive efforts to locate a standardized instrument, the researcher determined that constructing a custom assessment aligned with the specific instructional content was necessary. The test items were crafted based on the lesson objectives and designed to measure various aspects of reading comprehension, including decoding, vocabulary knowledge, and inferential thinking.

Validation of the test instrument was conducted in multiple stages. Initially, teachers from other schools with similar student demographics were invited to review the test items and provide feedback. Their comments, suggestions, and recommendations informed the first revision of the instrument. Subsequently, expert opinions were sought from the researcher's immediate superior and professors, who provided further insights into the second revision. These iterative revisions ensured that the test items were both valid and reliable for assessing the intended learning outcomes.

The study was conducted at Bugarin Elementary School chosen for its observed need to support learners with reading comprehension disabilities in improving their reading comprehension. The participants comprised 20 purposively selected students with specific learning disability in reading comprehension, representing a total enumeration of the target population. The purposive sampling technique ensured that the study focused on students who would most benefit from the intervention.

Ethical considerations were rigorously observed throughout the research process. Permission to conduct the study was secured by relevant authorities, including school administrators and parents or guardians of the participants. The confidentiality of the students' data was strictly maintained, and their participation was entirely voluntary.

Statistical treatment of the data involved the use of t-tests at a 5% level of significance. This statistical approach enabled the researcher to determine whether the differences in the pre-test and post-test performances of the experimental and control groups were statistically significant. By comparing the mean scores of the two groups, the researcher assessed the impact of TSI on students' reading comprehension. The analysis provided empirical evidence to support or refute the hypothesis that TSI significantly enhances reading comprehension among students with specific learning disabilities.

The experimental design of this study provided a robust framework for investigating the effects of transactional strategies instruction on reading comprehension. Through meticulous planning, validation, and statistical analysis, the study aimed to contribute valuable insights into effective instructional strategies for supporting students with specific learning disabilities in reading comprehension.

RESULTS:

Demographic Profile: Table 1 presents the demographic profile of the participants. The majority (60%) were 12 years old, with a gender distribution of 65% male and 35% female. All participants were in Sixth Grade and exhibited specific learning disabilities.

PROFILE	FREQUENCY	PERCENTAGE
Age		
11	6	30
12	12	60
13	2	10
	20	100
Gender		
Male	13	65
Female	7	35
	20	100
Grade Level		
Grade 6	20	100
Specific Learning Disability	20	100

Performance Before and After Intervention: Table 2 summarizes the reading performance of the participants. The mean pre-test score of 13.60 indicated an instructional reading level, while the mean post-test score of 24.15 demonstrated an independent reading level. These results suggest significant improvement in reading comprehension following the TSI intervention.

Test	N	Mean
Pre-Test	20	13.60
Post-Test	20	24.15
Test	**N**	**Mean**
Pre-Test	20	13.60

Significance of Difference: Table 3 shows the results of the T-test analysis. The significant difference between pre-test and post-test scores ($t = -8.81$, $p < .05$) confirms the effectiveness of TSI in enhancing reading comprehension among LSEN.

Test	N	Mean	SD	t-Test	p-Value	Remarks
Pre-Test	20	13.60	4.66	-8.81	1.03E-10	Significant
Post-Test	20	24.15	2.64			

DISCUSSION:

The findings from the study on students with Specific Learning Disability in Reading Comprehension provide valuable insights into their demographic profile, performance before and after a reading intervention, and the significance of changes observed. This discussion interprets these results within the context of educational practices, the efficacy of targeted interventions, and the implications for future research.

Profile of the Learner-Participants

Table 1 reveals a clear demographic profile of the SLD participants. The majority (60%) were 12 years old, 30% were 11 years old, and 10% were 13 years old. This age range is significant as it corresponds to typical middle school age, where foundational reading skills are crucial for academic success. Middle school students are at a critical juncture in their education, transitioning from primary to secondary education, where literacy skills become the foundation for advanced learning across disciplines (Chall, 1983).

Notably, there was a predominant representation of males (65%) compared to females (35%). This gender disparity aligns with existing literature indicating a higher prevalence of reading disabilities among boys (Ritchey & Heise, 2006). Research suggests that boys may experience greater challenges with reading acquisition due to a variety of factors, including differences in language development, attention span, and motivation (Brown, 2020; Gaskins et al., 2018). These findings underscore the importance of developing gender-sensitive approaches to literacy instruction that address these unique challenges.

All participants were in Grade 7, highlighting the critical nature of this educational stage. By seventh grade, students are expected to transition from "learning to read" to "reading to learn" (Chall, 1983). Addressing reading disabilities at this juncture is vital for preventing further academic struggles and ensuring students can engage with more complex texts in various subjects. The uniformity of the disability type—specifically reading disabilities—among all participants emphasizes the need for specialized interventions. This focused group allows for a concentrated examination of the effectiveness of reading programs tailored to this specific challenge, highlighting the necessity of individualized approaches in special education (Carrasquillo & Rodriguez, 2020).

Performance Before and After the Intervention

Table 2 illustrates a significant improvement in the performance of the learner-participants before and after the intervention. The pre-test mean score of 13.60 indicated that participants were operating at the "instructional" level, suggesting they could read with guidance but struggled to comprehend independently. After the intervention, the post-test mean score rose to 24.15, categorizing their performance as "independent." This improvement signifies not only enhanced reading ability but also greater confidence in tackling reading tasks autonomously.

The intervention's effectiveness aligns with the literature emphasizing the importance of targeted reading interventions for students with disabilities. Programs incorporating explicit instruction in reading strategies, phonemic awareness, and comprehension techniques have consistently produced positive outcomes (Gersten et al., 2017). Furthermore, the results validate the role of transactional strategies instruction (TSI), as highlighted by Brown et al. (2019), which integrates cognitive and metacognitive strategies to foster active reading and comprehension. The observed gains suggest that the intervention employed in this study adhered to evidence-based practices in special education, which prioritize scaffolded instruction and consistent progress monitoring (Applegate & Applegate, 2019).

Significance of the Intervention

Table 3 demonstrates a statistically significant difference between pre-test and post-test scores, with a t-ratio of -8.81 and a p-value of 1.03E-10. This strong statistical significance indicates that the null hypothesis—there is no significant difference before and after the intervention—should be rejected. The results imply that the reading intervention was not only effective but also impactful enough to warrant attention in future educational strategies.

The significant improvement in reading performance supports previous findings emphasizing the effectiveness of structured reading interventions. For instance, interventions employing systematic phonics instruction and comprehension strategies have been shown to produce significant gains in reading proficiency among students with reading disabilities (Ehri et al., 2001). Similarly, studies by Duke and Pearson (2020) highlight the importance of integrating direct instruction with opportunities for independent reading practice, a principle reflected in the design of this intervention.

The profile of the learner-participants and the significant improvements observed in reading ability post-intervention highlight several implications for practice in educational settings. Firstly, the findings suggest a pressing need for schools to implement targeted reading interventions for students with disabilities, particularly in grade six. Educators should focus on developing individualized education programs (IEPs) that incorporate specific reading strategies aligned with students' needs (Baker, 2020). Additionally, providing ongoing professional development for teachers on evidence-based reading strategies is crucial to sustaining and enhancing the effectiveness of such interventions.

The gender disparity noted in the participants raises questions about the need for gender-sensitive approaches in reading instruction. Future research could explore the reasons behind this discrepancy and investigate whether tailored strategies for boys and girls could further enhance reading outcomes. For example, studies have suggested that boys may benefit from interventions incorporating topics of high interest to them, which could increase engagement and motivation (Beck & McKeown, 2020; Ginting, 2019).

The effectiveness of the intervention also opens avenues for further studies. Future research should consider longitudinal studies to assess the durability of reading gains over time and explore the impact of interventions on other areas of academic achievement. Expanding the scope of the study to include a diverse range of disabilities beyond reading could provide a more comprehensive understanding of the generalizability of intervention strategies (Gersten et al., 2017). Moreover, exploring the integration of technology in reading interventions could provide insights into modern approaches that may engage students more effectively. Tools such as audiobooks, reading apps, and interactive platforms could complement traditional methods and cater to diverse learning styles (Julapho, 2018).

CONCLUSION:

The findings of this study provide compelling evidence for the effectiveness of Transactional Strategies Instruction (TSI) in enhancing reading comprehension among Students with Specific Learning Disability (SLD) in reading comprehension. The significant improvement in reading performance, as indicated by the difference between pre-test and post-test scores, confirms the efficacy of TSI as a powerful tool for addressing reading comprehension challenges.

The participants, initially performing at an instructional level, achieved an independent reading level after the intervention, demonstrating the potential of TSI to foster greater comprehension skills and confidence in learners with reading disabilities. This study highlights the importance of implementing evidence-based instructional strategies tailored to the needs of students with SLD, particularly at the critical middle school stage.

The observed gains in reading ability suggest that TSI's interactive and strategic approach, focusing on metacognitive and cognitive engagement with texts, can play a pivotal role in bridging reading gaps. Additionally, the findings underscore the need for educators to integrate such strategies into mainstream educational practices to better support students with diverse learning needs.

Integrating TSI into educational frameworks can lead to improved academic outcomes for students with SLD, contributing to more inclusive and effective literacy instruction. Future research should explore the long-term impact of TSI, the role of gender-sensitive approaches in reading interventions, and the integration of technology to further enhance learning experiences for students with SLD. As we move forward, it is essential that policymakers and educators continue to prioritize innovative, inclusive strategies that empower all learners to succeed academically and beyond.

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FACING THE FUTURE: HOW NON – IT PROFICIENT TEACHERS COPE WITH AI CHATBOTS IN EDUCATION

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ABSTRACT

The rapid integration of artificial intelligence in educational environments introduced a range of AI powered applications, such as ChatGPT, that promise to enhance teaching and learning experiences. However, this technological shift poses major challenges for educators who are not proficient in information technology. This study investigated the coping strategies of non-tech-savvy teachers as they navigate the complexities introduced by AI chatbots in teaching. This study employed multi-case study design. The participants consisted of five teachers from different schools in Ilocos Sur who belonged to the so-called "techno migrants" group. Data gathered through interviews underwent thematic analysis using the cool and warm technique to discover themes and patterns on their coping strategies and their AI readiness attitudes. Distinct challenges faced by each group were also determined. The findings suggest that while some teachers are well-equipped to embrace AI chatbots, others are wary and unsure which hinders their adoption and use of these tools. Addressing these challenges requires targeted support and strategies tailored to each category. This study concludes that teachers who devote time to learning new technologies and use them are more likely to adopt new technology and find ways to integrate them in their teaching. Whereas teachers who are wary and uncertain of new technology and find little time to learn about them are less likely to adopt new technology. These findings contribute valuable insights into how teachers deal with new AI technologies and how to motivate and empower teachers to use new technologies.

KEYWORDS: AI chatbots, ChatGPT, Non-tech-savvy teachers, AI-Coping strategies of teachers

INTRODUCTION

The rapid integration of artificial intelligence (AI) in education has transformed the way teaching and learning are conducted. AI-powered tools, particularly chatbots like ChatGPT—have been increasingly adopted for tasks such as automating administrative duties, offering personalized feedback, enhancing student engagement, and supporting differentiated instruction. These developments offer promising benefits for both educators and learners.

However, this technological shift also introduces significant challenges, especially for educators who are not proficient in information technology (IT). As schools and educational institutions strive to keep pace with innovation, non-tech-savvy teachers often find themselves struggling to adapt. This study investigates how these teachers cope with the complexities brought about by AI-chatbots, focusing on the strategies they use to navigate the evolving educational landscape.

Numerous studies affirm the educational potential of AI. Holmes et al. (2019) point out that AI can enhance learning outcomes through adaptive systems that personalize instruction. Luckin et al. (2016) argue that AI allows educators to focus on high-value tasks by automating routine work. Yet, the promise of AI is not universally realized due to the digital divide, which remains a barrier to equitable technology integration.

The digital divide refers to disparities in access to and effective use of information and communication technologies (ICTs), influenced by factors such as socio-economic status, geography, and institutional support (OECD, 2022). In the Philippine context, this gap is further exacerbated by regional disparities, logistical challenges, and limited ICT infrastructure (Pouezevara et al., 2020). As a result, many educators—particularly in underserved areas—lack the resources and skills necessary to integrate AI tools effectively.

Teachers play a vital role in creating meaningful and engaging learning environments. However, not all educators are digitally prepared to use AI tools in their classrooms. Studies have shown that some teachers lack the experience to conduct data analysis, customize AI-generated assignments, or interpret AI feedback (Ally, 2019; Seo et al., 2021). Concerns also exist about AI's limitations, such as inaccurate outputs, lack of transparency, and ethical ambiguities (Akgun & Greenhow, 2021; Sijing & Lan, 2018).

Emotional and psychological responses also play a role in teachers' willingness to adopt new technologies. According to Cicero (2024), successful technology integration requires affective commitment, which includes: a positive attitude toward technology, belief in one's ability to use it, and alignment with the broader vision of innovation in education.

Wang et al. (2023) identified four key components of AI readiness among teachers: cognition, ability, vision, and ethics. Their study categorized educators into three readiness clusters and found that higher levels of AI readiness were associated with lower perceived threats, higher job satisfaction, and more innovative practices. Interestingly, the study noted no significant differences based on gender or socio-economic region, suggesting that AI readiness is more influenced by institutional and individual support structures than demographic factors.

For many educators, especially those who are less experienced with digital tools, the adoption of AI is their first encounter with such advanced technologies. Prothero (2024) identified key barriers for these teachers, including concerns about AI's societal impact, data privacy, lack of professional development, and limited institutional guidance. These issues discourage both potential adopters and current users of AI tools.

Technological anxiety—often termed "technophobia"—can further inhibit adoption. Musa et al. (2022) describe emotional responses ranging from optimism to fear when new technologies are introduced. Li and Huang (2020) categorize AI-related anxieties into several types, including learning anxiety, ethical concerns, loss of privacy, fear of job replacement, and existential threats associated with AI autonomy.

Despite these challenges, literature suggests several coping strategies for non-IT proficient educators:

Professional Development and Training: Targeted training initiatives have proven effective in building teachers' technological competence. Tondeur et al. (2017) found that workshops, peer mentoring, and access to resources helped teachers become more confident and capable in using technology.

Collaborative Learning Communities: Peer support and knowledge-sharing within professional networks ease the transition to new technologies. Vangrieken et al. (2017) emphasize that collaboration fosters innovation and mitigates resistance to change.

Self-Directed Learning and Growth Mindset: Teachers' beliefs and attitudes significantly influence their willingness to adopt technology. Ertmer and Ottenbreit-Leftwich (2010) assert that when educators perceive technology as valuable, they are more likely to invest in learning how to use it. Nonetheless, systemic barriers remain. A 2021 report by the National Education Association (NEA) highlights ongoing challenges such as inadequate infrastructure, limited technical support, and the absence of clear institutional policies. Senior teachers, in particular, may resist adopting new tools due to perceived difficulty, lack of time, or doubts about efficacy (Talvid, 2014). His study identified common reasons for resistance, including low technical competence, insufficient resources, fear of losing classroom control, and skepticism about long-term value.

Conclusion

While AI-chatbots like ChatGPT hold transformative potential in education, non-IT proficient teachers face numerous obstacles in embracing these tools. This study seeks to understand how such educators cope with the challenges of AI integration by examining their strategies, mindsets, and support systems. By shedding light on their experiences, the research aims to inform the development of inclusive training programs, supportive policies, and institutional frameworks that empower all teachers—regardless of technical skill—to thrive in an AI-enhanced educational environment. Ultimately, this study intends to provide meaningful insights for school administrators, curriculum developers, and teacher training institutions to craft responsive, relevant, and inclusive approaches to AI integration in education.

METHODOLOGY

This study aimed to explore how non-IT proficient teachers cope with the use of AI-powered chatbots such as ChatGPT in educational settings.

Research Design

A qualitative **multi-case study design** was employed for this research. A multi-case study involves selecting and analyzing two or more cases that share common characteristics but also differ in certain aspects (Mehta, 2024). This approach enables researchers to draw comparisons, identify patterns, and derive deeper insights through cross-case analysis. The multi-case study design was particularly suited to this investigation as it allowed for a detailed examination of various cases involving non-IT proficient teachers across different school contexts. By probing into their individual experiences, apprehensions, and coping mechanisms in using AI-powered tools like ChatGPT, the researchers were able to uncover the unique and shared challenges these teachers encounter. This

approach enriched the depth and breadth of understanding, ultimately strengthening the validity and transferability of the findings.

Study Site and Participant Selection

The study was conducted in multiple schools within **Ilocos Sur**, encompassing both high schools and higher education institutions. The participants were selected through **purposive sampling**, targeting teachers who were known or observed to be non-IT proficient. Special focus was given to individuals categorized as "techno-migrants," particularly those aged between **40 to 60 years**, to ensure that the study captured the specific struggles and strategies of older educators adapting to emerging technologies.

This purposeful selection allowed the researchers to zero in on participants who were most relevant to the study objectives, those facing technological challenges and undergoing transitional experiences with AI tools.

Data Collection Procedures

The data collection process was structured into three distinct stages:

1. Pre-Data Gathering

1. Developed a preliminary profile of potential participants.
2. Designed, reviewed, and finalized as an interview guide.
3. Secured permission from school administrators.
4. Distributed informed consent forms explaining the study's purpose and participants' rights.

2. Actual Data Gathering

1. Conducted individual, face-to-face interviews at participants' respective schools.
2. Used audio and/or video recording tools with participant consent.
3. Maintained an informal interview setting to encourage openness and deeper sharing of experiences.

3. Post-Data Gathering

1. Transcribed all recorded interviews verbatim.
2. Conducted thematic analysis using Cool and Warm Analysis to identify recurring patterns, categories, and themes.
3. Synthesized insights and interpretations regarding teachers' challenges and coping strategies when using AI tools.

Ethical Considerations

The study followed rigorous ethical standards to protect participants' rights and welfare. Participation was voluntary, and informed consent was obtained from all individuals involved. Participants were informed of the study's purpose, potential benefits, and their right to withdraw at any time.

To ensure confidentiality and anonymity, no personal identifiers were used, and all data were treated with the highest level of discretion. The research process was grounded in respect, integrity, and adherence to accepted ethical practices.

Mode of Analysis

The study employed Thematic Analysis, following the six-phase framework proposed by Braun and Clarke (2006):

1. **Familiarization**
   - Immersion in the data through repeated readings of interview transcripts.
2. **Generating Initial Codes**
   - Systematic coding of meaningful data segments related to the research questions.
3. **Searching for Themes**
   - Grouping codes into potential themes that reflect patterns across cases.
4. **Reviewing Themes**
   - Refinement and validation of themes for internal coherence and representativeness.
5. **Defining and Naming Themes**
   - Articulation of each theme's meaning, scope, and relevance to the study.
6. **Producing the Report**
   - Compilation of findings into a structured narrative, supported by direct quotes and examples from participants.

RESULTS AND DISCUSSION

Theme: Coping Strategies of Teachers in Adapting to AI-Powered Chatbots

Understanding teachers' perspectives and attitudes towards technology is essential for successful adoption, especially in an era of rapid digital transformation in education. This study explored how non-tech-savvy teachers cope with the emergence of AI tools like ChatGPT, highlighting their strategies, concerns, and readiness levels.

The responses revealed varied reactions to the use of AI-powered chatbots. While some teachers embraced ChatGPT with enthusiasm and a proactive mindset, others displayed caution, skepticism, or hesitation. Despite these differences, a shared willingness to learn and grow was evident among all participants. Most teachers still prefer using conventional tools like Google or Google Scholar and expressed difficulty in evaluating student outputs created with the help of AI.

From the data, four subthemes emerged, representing the spectrum of attitudes and coping mechanisms: (1) The AI-Ready Teacher, (2) The AI-Adaptive Teacher, (3) The AI-Wary Teacher, and (4) The AI-Reluctant Teacher. Although the concept of an AI-Apathetic Teacher was considered, none of the participants exhibited complete indifference to AI integration.

Subtheme 1: The AI-Ready Teacher

This teacher demonstrated fluency with AI tools and confidence in integrating them into teaching. She explained:

"ChatGPT helps me be more organized in making essays and other literary stuff. It gives ideas on unfamiliar topics… With ChatGPT, work is shortcut. Of course, you cannot rely solely on it, but it helps you focus."

Notably, she also emphasized the importance of digital literacy among students:

"Since ChatGPT has a big influence on education, let's just remind our students of its proper use and ensure that sources are reliable."

Interpretation and Implication:

The AI-Ready teacher exemplifies a forward-thinking mindset and understands AI as both a productivity enhancer and a tool that requires critical oversight. These educators can serve as catalysts within their institutions—mentoring peers, piloting AI-driven instructional strategies, and shaping policies on responsible AI use. Their comfort with technology allows them to guide students in using AI tools ethically and effectively. This aligns with Ertmer and Ottenbreit-Leftwich (2010), who emphasized that teacher confidence and pedagogical beliefs significantly influence the integration of technology in education. Similarly, Gill et al. (2024) note that early adopters of AI like ChatGPT can shape the learning environment by modeling ethical and effective use.

Subtheme 2: The AI-Adaptive Teacher

This teacher had only recently adopted ChatGPT, encouraged by peers in graduate school:
"I usually use Google, and sometimes Google Scholar. But now, I use ChatGPT to get ideas, organize my thoughts, and find information quickly.

She recognized the benefits but stressed the importance of responsible use:
"Ang susi ay ang paghahanap ng paraan para isama ito sa pag-aaral na nag-eencourage ng critical thinking at independent learning…"

(*The key is finding ways to integrate it into learning that encourages critical thinking and independence.*)

Interpretation and Implication:

AI-Adaptive teachers are in a transitional phase—receptive to innovation but needing structured guidance and peer support. They reflect the potential of professional development in increasing AI acceptance. With proper mentoring and training, these teachers can confidently implement AI tools in ways that support active learning rather than passive consumption. This finding is consistent with the study by Musa Adekunle Ayanwale et al. (2022), which found that teachers' readiness to adopt AI is closely linked to institutional support and training opportunities. It also resonates with Ng et al. (2023), who reported that teachers develop stronger AI digital competencies through collaboration and targeted development programs.

Subtheme 3: The AI-Wary Teacher

This teacher had minimal experience with ChatGPT, using it only after a recent training session. While she saw its potential, she was not yet ready to adopt it fully:
"I think it's important to understand how to use ICT tools properly. I need to explore ChatGPT more and understand its ethical implications before I decide.

She expressed concern over students' uncritical use of AI tools:
"Some students use it to get quick answers without analyzing… I don't let them use it in class."

Interpretation and Implication:

The AI-Wary teacher highlights the importance of digital ethics and data accuracy in AI

adoption. Her cautious stance stems from a genuine desire to protect pedagogical integrity. These educators may benefit from workshops focused on ethical use, verification of AI-generated content, and the development of lesson plans that incorporate AI while reinforcing critical thinking. This aligns with Jian Li and Huang's (2020) discussion on AI anxiety, where uncertainty about ethical use was a key barrier. It also echoes concerns in Holmes et al. (2019), who argued that the responsible use of AI in education must include ethical and pedagogical considerations.

Subtheme 4: The AI-Reluctant Teacher

This participant showed limited awareness of AI tools and admitted low IT confidence:
"Hindi ako gaanong pamilyar sa mga advanced technologies… I'd rate myself a 1 because I'm not IT efficient, but I see to it I learn from my daily work."

Despite her reservations, she recognized the importance of growth:
"I would prefer classroom activities that focus on critical thinking and not just getting quick answers from a machine."

Interpretation and Implication:

The AI-Reluctant teacher underscores a critical barrier: lack of digital confidence. These educators may perceive AI as a threat to traditional pedagogical methods or as a tool beyond their capacity. Professional development efforts must address these emotional and cognitive barriers by offering low-pressure, hands-on workshops and fostering a supportive learning community that values gradual progress. This corresponds with Hyndman (2018), who listed low confidence and fear of failure as key reasons teachers hesitate to use technology. Tallvid (2014) similarly noted that reluctance often stems from limited experience and training in pedagogical technology integration.

Teacher Type	Attitude Towards AI	Needs for Support
AI-Ready	Enthusiastic and proactive	Serve as mentors; advance digital literacy
AI-Adaptive	Open but inexperienced	Training, peer collaboration, guided integration
AI-Wary	Cautious and evaluative	Ethical discussions, tool evaluation frameworks
AI-Reluctant	Resistant and lacking confidence	Basic digital skills, motivational support

Summary and Implications

These findings highlight that while enthusiasm exists among some educators, others require a supportive environment to overcome hesitancy or fear. The study reveals a pressing need for differentiated professional development programs that take into account the varying levels of AI readiness.

To successfully integrate AI tools in education, institutions must adopt a human-centered approach—recognizing that digital transformation depends not only on tool availability but also on teacher mindset, capacity, and support. Building digital confidence, fostering collaboration, and promoting ethical AI usage are key strategies to bridge the readiness gap among educators.

CONCLUSION

The successful integration of artificial intelligence (AI) in education largely depends on the readiness and willingness of teachers. As key facilitators of learning, teachers play a vital role in preparing students not only to understand AI, but also to navigate a future where human-AI collaboration is increasingly prominent. Their openness, confidence, and competence in using AI tools such as ChatGPT directly influence the effectiveness of AI implementation in the classroom.

This study found that non-tech-savvy teachers, while initially relying on traditional tools like Google for academic information, have shown varying responses to AI chatbots. Some participants demonstrated curiosity and began experimenting with ChatGPT after exposure through peer recommendations or professional development. Others remained hesitant or resistant due to anxiety, unfamiliarity, and a perceived lack of institutional support.

To address this disparity, the study proposed four categories of teacher responses to AI—**AI-Ready**, **AI-Adaptive**, **AI-Wary**, and **AI-Reluctant**. These classifications provide a useful framework for understanding the diverse attitudes and coping strategies of teachers when faced with emerging technologies. More importantly, they highlight the need for differentiated, targeted support and professional development programs that respond to each group's specific concerns and capabilities.

In conclusion, empowering teachers to embrace AI technologies is not just a matter of access, but of mindset, training, and institutional backing. Supporting educators through tailored strategies and ongoing guidance will be essential to fostering their confidence and equipping them to prepare students for a future shaped by human-AI collaboration.

RECOMMENDATIONS

The findings of this study emphasize the importance of designing targeted support systems that align with the varying levels of AI-readiness among teachers. To promote effective and inclusive AI integration in education, the following recommendations are proposed:

1 **Tailored Professional Development and Training Programs**

1.2 **Differentiated Learning Tracks**: Develop training programs based on teachers' AI-readiness levels.

1.2.1 *AI-Ready* and *AI-Adaptive* teachers can benefit from advanced workshops on integrating AI for higher-order tasks like assessment design, differentiated instruction, or AI-supported research.

1.2.2 *AI-Wary* and *AI-Reluctant* teachers should be offered beginner-friendly sessions that focus on building confidence, addressing misconceptions, and demonstrating basic, practical classroom applications of AI chatbots.

1.3 **Sustained Mentorship**: Pair less tech-savvy teachers with more experienced mentors who can provide guidance, modeling, and reassurance through regular check-ins and co-teaching opportunities.

2 **Establishment of Collaborative Learning Communities**

2.2 **Peer-Led Support Networks**: Facilitate communities of practice where teachers can openly share their experiences, challenges, and success stories using AI chatbots. This peer interaction fosters a sense of community and helps normalize the learning process.

2.3 **Interdisciplinary Collaboration**: Encourage collaboration across subject areas by forming support teams that include educators with varying degrees of tech proficiency, allowing for cross-pollination of ideas and mutual learning.

3 **Use of Evidence-Based and Reflective Practices**

3.2 **Pilot Initiatives**: Launch pilot projects that allow teachers to experiment with AI chatbot integration on a small scale. Gathering and showcasing positive outcomes can help ease the skepticism of *AI-Wary* and *AI-Reluctant* teachers.

3.3 **Ongoing Evaluation**: Implement mechanisms to regularly assess the impact of AI tools on student engagement and learning outcomes. These insights can guide iterative improvements to both pedagogy and training programs.

4 **Improvement of Technical Infrastructure and Support**

4.2 **Access to Technology**: Ensure schools are equipped with adequate hardware, stable internet connectivity, and updated software that supports the smooth operation of AI tools like ChatGPT.

4.3 **Dedicated Technical Assistance**: Offer accessible tech support that can quickly address teachers' operational concerns, reduce frustration and minimizing resistance due to technical difficulties.

5 **Cultivating a Positive and Purposeful Tech Mindset**

5.2 **Promoting Growth-Oriented Attitudes**: Encourage teachers to see AI integration not as a threat to traditional teaching but as an opportunity to enhance instruction and develop new professional competencies.

5.3 **Connecting AI Use to Instructional Goals**: Emphasize the practical value of AI chatbots by aligning their use with classroom challenges—such as reducing workload, organizing content, or facilitating inquiry-based learning—making the benefits more tangible for hesitant educators.

By implementing these targeted strategies, educational institutions can create a supportive and responsive environment that empowers all teachers—regardless of their tech proficiency—to gradually and confidently incorporate AI chatbots into their teaching. Ultimately, this supports both teacher growth and student readiness for a future shaped by human-AI collaboration.

LIMITATIONS

While this study offers valuable insights into the coping mechanisms of non-IT proficient teachers in relation to the use of AI chatbots, several limitations must be acknowledged. Firstly, the small sample size and the focus on a specific group of teachers may limit the generalizability of the findings. Despite this, the study sheds light on the varying attitudes and reactions of teachers towards AI technologies, contributing meaningful awareness to this emerging area.

Future studies would benefit from using a larger and more diverse sample, as well as incorporating additional data collection methods such as classroom observations or focus group discussions to triangulate findings and enrich the analysis. Exploring the potential negative impacts of chatbot usage is also recommended to identify specific challenges and inform the development of more effective, user-centered AI tools for education.

Moreover, while the research successfully met its objectives, it also raised new questions—particularly regarding how students perceive their teachers' competence in using AI technologies. Investigating this perspective may offer a more holistic understanding of AI integration in the classroom.

Future research should also explore variations in teachers' responses based on subject specialization and academic level. Comparative studies between teachers from different disciplines and grade levels could uncover nuanced differences in how AI tools are perceived and utilized, thereby informing more tailored and effective support mechanisms.

Finally, it is important to note that educational technology, particularly AI chatbot integration, remains a rapidly evolving field. Its implementation in education—especially in higher education—continues to develop, and as such, more comprehensive and longitudinal research is needed to fully understand its implications, benefits, and limitations.

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CARRYING THE TORCH OF LIFELONG LEARNING: A GROUNDED THEORY ON THE SIGNIFICANT PERSPECTIVES AND EXPERIENCES OF LIFELONG LEARNING ADVOCATES

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ABSTRACT

This grounded theory study endeavored to generate a framework for lifelong learning among educational leaders. It explores the perspectives and lived experiences of thirteen purposefully selected educational leaders, interviewed face-to-face as key informants, to understand their roles as advocates of lifelong learning. Findings reveal that lifelong learning is perceived as a powerful tool for promoting mental acuity, fostering meaningful relationships, enhancing personal skills, and driving transformative changes. Lifelong learners were described as analytical, emotionally mature, and skillful. Data analysis indicates that educational leaders engage in lifelong learning through ongoing experiences and activities by participating in diverse learning opportunities, reinforcing values formation, and committing to continuous personal and professional development. This study holds significant implications for policy formulation, educational leadership practices, professional growth, and community engagement. It advocates for inclusive policies that ensure equitable access to lifelong learning opportunities across K–12, higher education, and adult education. Government agencies may leverage the findings to integrate lifelong learning into national educational policies, prioritize funding for employee education, and promote partnerships between educational institutions and community organizations. Furthermore, the study encourages a culture of continuous improvement, where leaders explore innovative learning avenues, pursue self-directed learning, invest in time and resources in professional development. It also aims to increase public awareness, expand access to educational resources and mentorship, and promote community involvement. Finally, it calls for the recognition of lifelong learning advocates through certification and awards to inspire participation and commitment.

KEYWORDS: *lifelong learning, educational management, grounded theory, experiences*

INTRODUCTION

"You have a lifetime to learn to live. We learn not for school, but for life." – Seneca

Man's quest for learning does not stop at school when one has been donned with the tassel and gown; neither does it end when an individual has reached the highest peak of academic success. Continuous learning is a process of life; it is as vital as the air humans constantly breathe. From the moment a person is born until he dies, it remains to be one of the fundamental mechanisms for his survival.

Friesson and Anderson (2004) define the term “lifelong learning”, as learning that takes place at all stages in one’s life cycle. It requires that learning outcomes emanate from different settings and situations.

Ahmed (2009) outlines that lifelong learning embraces all forms of learning experiences that help individuals engage in meaningful interactions with surroundings through the enhancement of one’s knowledge, competence and critical thinking abilities.

Additionally, Nissen and Jivanjee (2014) share their standpoint on the concept of lifelong learning as a set of values and principles regarding the role of continuing acquisition, integration, and application of new knowledge throughout one’s life.

Lifelong learning has a long history. A previous conception of lifelong learning states that it was termed as lifelong education instead of learning, “recurrent education”, “education permanente” or “the learning society” (Merrill & Hyland, 2003).

Laal (2004) further states the core concepts of the different forms of learning which include formal, informal, and non-formal learning. Formal learning consists of learning that occurs within a planned and structured context that leads to formal recognition such as being given a certificate or diploma. Informal learning is learning resulting from daily life activities related to family, work, or leisure or otherwise known as experiential learning. While non-formal learning consists of learning embedded in planned activities that are not explicitly designated as learning, but which can contain important learning elements such as vocational skills acquired at the workplace.

Lifelong learning involves vocational and technical education, the wide ranges of including, during, and excluding the learning process. It is a beneficial opportunity that provides equality for individuals and a process where there is no existence of time, place, age, socio-economic, or even education level (Gunuc, 2012).

Lifelong learning provides learners with the tools that will aid them in their learning. The European Commission’s definition of lifelong learning is “all learning activity undertaken throughout life, with the endeavor of advancing the knowledge, skills, and competencies within a personal, civic, social or employment-related perspective” (Longworth, 2003).

Lifelong learning and achievement motivation are two important concepts that play a significant role in not only school life but also the acquisition of required survival skills throughout one’s life. If an individual is equipped with lifelong learning skills and achievement motivation, he or she will probably succeed in life as the need to learn and succeed will never end. “The motivated person is a lifelong learner and a lifelong learner is a motivated person” (McCombs, 1991).

To further crystallize the significance of lifelong learning, a body of literature in the local setting is presented.

Macaranas (2017), in his study “Lifelong Learning in the Philippines”, succinctly stated that the International Labour Organization (ILO) adopted a new instrument on human resource development which highlighted education, training, and lifelong learning as a key to economic and

employment development. The ILO described lifelong learning as all learning activities leading to the enhancement of competencies and qualifications. In this sense, competence was defined by ILO as something that covers the knowledge applied and mastered in a precise context, while qualifications as a formal expression of the vocational or professional abilities duly recognized by either worldwide or sectoral levels. Meanwhile, the Organization for Economic Cooperation and Development (OECD) articulates that lifelong learning is all learning occurring between cradle and grave, from early childhood to training of people beyond their retirement to provide opportunities to create not just any job, but jobs of quality. He further added that the foundations for lifelong learning policy in the Philippines are the requirements of the 1987 Constitution. Lifelong learning is also stipulated in the Medium-Term Philippine Development Plan (MTPDP) for 2005-2010 where MTPDP recognizes the significance of lifelong learning. MTDTP mentions this statement on lifelong learning, "In a world where knowledge has been a crucial element for nations to prosper and compete, primacy is placed on quality and accessible lifelong learning, from early childhood development to primary, secondary, and tertiary learning".

In like manner, the Philippine Plan of Action (PPA) for Education for All or EFA of 1991 to 2000, was cited at the EFA World Conference. The "new revolution" in education in terms of a lifelong learning policy under the 2005-2010 MTPDP was highlighted outlining that the government will refrain from offering programs also being offered by the private sector to channel government resources to areas where efficiency and effectiveness are greater, to create a learning society where people continue to learn on their own, improving the quality of life, and contributing to national development. The EFA Plan was the government's commitment to providing all Filipinos with at least basic education by the year 2000. However, this target was not accomplished. Hence, the country recommitted similar goals for the Millennium Development Goals (MDGs) on education. But some challenges hinder meeting the said goals which include the bureaucratic capacity to respond to domestic and international challenges and the national budget as well.

After a thorough reading of the body of literature, it was realized that there is a limited number of studies on lifelong learning in the local context. Hence, the said gap was considered in the conceptualization of the study.

This study primarily aimed to develop a model-framework that would theorize the promotion of lifelong learning among educational leaders. Specifically, this qualitative type of research was guided by the following essential objectives: (1) describe the *advocates' perspectives on lifelong learning*, (2) describe the advocates' *significant experiences on lifelong learning*; and (3) describe the *general structures and characteristics of lifelong learning programs/culture* in the advocates' respective organization or workplace.

It is hoped that the results of this study will provide the following benefits:
As part of an educational leaders' role in creating an impact in society, it is hoped that the findings of this study would develop a framework on lifelong learning for educational leaders. The output of this research may serve as a proposed paradigm for educational leaders that may fit the local context in adapting lifelong learning.

The findings of the study may foster a love for continuous learning and ignite passion among educators to create meaningful contributions in the workplace.

The study may serve as a source of inspiration to those who are not in the educational or academic sector. Moreover, it may serve as a guide to researchers who are doing the grounded theory method in qualitative research. Finally, this study may serve as an enriching contribution to the existing body of knowledge in the field of research and educational management.

METHODS

This qualitative research employed a grounded theory method. Grounded theory was initiated by Glaser and Strauss (2017) and is a method founded on the premise that the generation of theory or framework is essential for a deep understanding of social phenomena.

The participants of the study were purposely selected based on their relevance to the research topic. The participants were thirteen (13) educational leaders: two (2) schools division superintendents, two (2) assistant schools division superintendents, one (1) public schools division supervisor, three (3) education program supervisors, two (2) elementary school heads and three (3) secondary school heads.

The following criteria were the basis for choosing the participants: (1) participants are educational leaders who are all advocates of lifelong learning; (2) participants are excelling well in the field of educational management whose ages range from 45-65 years old; (3) most of them have already finished their graduate studies and the others are currently pursuing graduate school; (4) the elementary and secondary school head participants were nominated as Most Outstanding Principals in the region.

The criterion-referenced sampling strategy was utilized in qualifying these participants. Creswell et al. (2009) defined the strategy as considering all cases that meet the criteria set as regards the nature and requirements of the study which is useful for quality assurance. In-depth interviews and observations are two sources of data usually employed in a grounded theory study. The source of data that was used is from the in-depth interview of lifelong learning advocates. The content of the open-ended interview guide was validated by experts in the field of educational leadership, qualitative research, and lifelong learning.

The following steps were undertaken in gathering the data for the study: The researcher sought permission from the right person in authority through a formal letter. Approved letter of request from the Dean of the Graduate School as well as the Division Superintendent's Office was sought. Upon approval, the researcher sent a letter of request and letter of consent to the participants as a part of the protocol or ethical consideration when interviewing participants in a study. Validation and approval of the research instrument from experts were considered before the scheduled interview was conducted. After the participants accepted the invitation, both the participant and researcher agreed to a convenient time for the interview.

An interview guide was also sent to the participants to prepare them for the actual interview. An orientation about the objectives of the study was also given beforehand. Permission to use an audio recorder was made. Moreover, informed consent was signed by each participant to assure the key

informants that the data gathered will be treated with the utmost confidentiality and will be used for research purposes only.

The data gathered from the interview was recorded and transcribed by the researcher. Treatment of data was made by employing the three levels in analyzing data in grounded theory: open coding, axial coding, and selective coding. The researcher compared and checked the relationship among responses to extract the similar concepts interrelated to one another to come up with a code to represent the extracted idea.

Allan (2003) describes the data analysis in the grounded theory as a process that involves searching for concepts by looking for codes, then concepts, and finally categories. According to Allan, "coding" as a form of content analysis, is used to discover the fundamental issues in data. In the data analysis, the interviewee uses phrases that pertain to the issue in the research. These issues are going to be mentioned and noted again, this is the process called coding and the short descriptor phrases are called "codes".

The data were analyzed after the coding of the key points from the transcriptions. The study made use of "key point coding". Merriam SB and Associates (2002) discuss that coding has three levels in analyzing the data: open, axial, and selective coding. In the open coding, the data were broken down to allow the beginning of the process of categorization. Axial coding takes initial categories and makes further comparisons that describe relationships between categories. Using selective coding, saturation of categories is examined, which means that further analysis produces no new information or need for additional categories. In short, all the data were captured and described by key categories and a core category emerged that tells the central story of all participants as a group. This core category afterward was used to develop an emerging theory and conceptual framework that is considered grounded in the data and reflective of the lived experiences of all participants.

The study also made use of the key point coding where points regarded were identified in the transcript and were given an identifier. Identifiers were marked EL to signify "Educational Leader" with the corresponding number, i.e. EL1 which refers to an educational leader or participant number 1. After assigning codes to the key point, these "codes" were scrutinized and were categorized in a table. From the said codes, or known as concepts, surfaced other common concepts, or called "categories" which led eventually to "emerging themes".

Coding, as a form of heuristics, is an exploratory problem-solving technique without specific formulas to follow. It is only the initial step toward an even more rigorous and evocative analysis and interpretation. It is not just labeling, it is linking. It leads researchers from the data to the idea, and from the idea to all the data of that idea (Bryant & Charmaz, 2007).

After the codes have reached saturation and had been categorized according to their commonalities, an external validator's expertise was sought to check the produced categories. These categories underwent constant review and scrutiny before they led to the emergence of the themes.

FINDINGS

This section presents the findings of the study. The general objective of the study is to develop a model framework that emerges from lifelong learning advocates' significant views and experiences. Specifically, it seeks to describe: 1) the participants' perspectives on lifelong learning, (2) the characteristics of lifelong learning advocates, (3) the significant experiences and activities of educational leaders on how to become lifelong learners, (4) factors that influence educational leaders to become lifelong learners and; (5) initiatives to promote lifelong learning and ways to strengthen lifelong learning skills and attitudes.

DISCUSSION

As derived from the findings of the study, the participants' perspectives on lifelong learning are lifelong learning fosters a love for learning, cultivates valuable relationships, scaffolds one's aptitude and dexterities; and creates transformation. Common themes conveyed in the literature on lifelong learning articulate characteristics which describe the perspectives of the participants on the concept of 'lifelong learning'.

The findings of the study revealed that lifelong learning fosters a love for learning. Fostering love for learning means having a nurturing passion and desire to learn. Accounts from the educational leaders' responses stated they have developed a high desire to learn and continuously learn on a deliberate basis and in greater depth. These findings were supported by the following body of literature. As a result of lifelong learning, people improve in their cognitive functioning.

Analysis of the study indicates that lifelong learners are characterized as analytical and perceptive. Being analytical is having the ability to critically examine situations. Being perceptive is about being a keen observant or being discerning. These two traits are essentially needed by an educational leader as this will help in making important decisions and solving critical situations that confront him/her as a leader of the organization. As a learner himself, being an analytical educational leader also means choosing and implementing appropriate learning strategies and reflecting on and evaluating one's learning.

CONCLUSION

After a thorough analysis of the study, the following conclusions were established: Lifelong learning is viewed by educational leaders as a vehicle in promoting mental sharpness, cultivating valuable relationships, scaffolding one's dexterities, and creating transformation. Lifelong learners are described as analytical, emotionally mature, and skillful. They are generally described as resilient, flexible, determined, humble, passionate and highly motivated, empathetic, optimistic, well-rounded, productive, competent, and socially involved.

Educational leaders learn throughout their life through the experiences and activities that they continually undertake by engaging in various learning opportunities to acquire and advance one's knowledge, by strengthening values formation, and by continuous learning for personal and professional development. By pursuing further studies, attending capability training and seminars,

putting a premium on research, learning through daily experiences are seen as opportunities for the educational leaders' personal growth and development.

The meaningful learning experience is the most important factor that shaped the educational leaders in becoming lifelong learners. Educational leaders, who played a pivotal role in affecting the climate, attitude, and reputation of their schools, make use of their meaningful learning experiences as a great way to make them metamorphoses as effective leaders. Moreover, through these learning experiences, educational leaders become the cornerstone on which learning communities' function and grow. Thus, schools become effective incubators of learning where students, teachers, and staff as well as community people are not only educated but also nurtured and empowered. To promote and strengthen lifelong learning skills and attitudes of educational leaders, they may facilitate reflective and practice-based learning, promote love for learning, strive in pursuit of holistic education and develop people for lifelong learning.

The Emerging Framework

The findings and the conclusions arrived at led to the emergence of a framework of lifelong learning. Figure 1 schematically presents the main themes formed based on the findings. Appropriate visual symbols are added to the illustration to enrich the total meaning of the framework (*please see next page*).

Figure 1

Miranda's Framework on Lifelong Learning for Educational Leaders

Figure 1: Miranda's Framework on Lifelong Learning for Educational Leaders

The torch, which is an emblem of both enlightenment and hope, symbolizes lifelong learners who would eventually reconstruct and revolutionize society.

Discussing the framework from the bottom, the handle of the torch embodies the significant experiences and activities to become lifelong learners which include engaging in various learning

opportunities, strengthening values formation, continuous learning for personal and professional development. The handle is gold colored to signify courage and compassion.

In the figure, the torch is being held by a hand that denotes the initiatives to promote lifelong learning and ways to strengthen lifelong learning skills and attitudes. These initiatives include facilitating reflective and practice-based learning, promoting love for learning, and striving in pursuit of holistic education. Brown is used to symbolize strength and dependability.

The fingers holding the torch stand for the characteristics or attributes of the educational leaders: analytical, skillful/competent, and emotionally mature. This means that they must possess these qualities so they can confidently embrace the experiences and activities needed to become a lifelong learner.

Moreover, a circle with the words *meaningful learning experience* is used to signify that meaningful learning experience is a major factor that shapes an educational leader to be a lifelong learner. It is colored green to signify life and regeneration.

Lastly, at the apex of the figure, is the burning flame from the torch that symbolizes the impact that lifelong learners can create after undertaking all the activities and experiences. It has three combinations of colors red, yellow, and orange. All these colors combined would mean power, passion, and wisdom to mean that lifelong learners are eventually able to produce a huge impact in the world.

The torch also symbolizes "the light" that lifelong learning advocates can create in the world. *Lifelong learning advocates may serve as "light" that guides humanity leading to self-actualization and personal mastery*. Lifelong learning, from the overall figure which is in color green (signifies regrowth and continuous learning), is now described to rediscover the meaning of our experiences by continuously undergoing the process of learning.

Abbreviations

LL - Lifelong Learning
MDG - Millennium Development Goals
ILO - International Labour Organization
GT - Grounded Theory
OECD - Organization for Economic Cooperation and Development
MTPDP - Medium Term Philippine Development Plan
EFA - Education for All

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MATHEMATICS PERFORMANCE OF GRADE 1 ADVANCED LEARNERS BASED ON THE YEAR-END ASSESSMENT: BASIS FOR A PROPOSED ENRICHMENT PROGRAM

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ABSTRACT

This study examined the mathematics performance of Grade One advanced learners in the Division of Makati City amid increasing expectations for high academic achievement. Although these learners were identified as advanced based on consistent academic performance and teacher recommendations, assessment results indicated that not all learners consistently achieved the target mastery benchmark of 82 percent, particularly in higher-order skills. (Assessment Practices of Teachers Implementing the Philippines and Singapore Elementary Mathematics Curriculum, 2024, pp. 46-60) Using a descriptive–developmental–evaluative research design, the study analyzed learners' performance using a school-based Year-End Mathematics Assessment aligned with Grade One curriculum standards. Descriptive statistical tools, including frequency counts, percentages, and mean scores, were employed to examine performance across selected mathematics competencies. Findings revealed strong proficiency in basic numeracy skills such as counting, addition, and subtraction; however, lower performance was observed in problem-solving and mathematical reasoning tasks. (Caberte et al., 2023, pp. 1-9) Based on these findings, a Mathematics Enrichment Program for Grade One advanced learners was proposed to address learning gaps, enhance conceptual understanding, and sustain learners' academic growth. The study emphasizes the importance of assessment-driven enrichment and differentiated instruction in early mathematics education.

Keywords: *mathematics performance, Grade One advanced learners, descriptive research, Mathematics Enrichment Program, Makati City*

INTRODUCTION

In a globalized and technology-driven society, education prepares individuals to meet rapid social, economic, and technological change. In the Philippines and across ASEAN, national development and global competitiveness rely on quality education and strong foundational learning in the early years. As technology shapes modern life, mathematics is a key discipline that supports reasoning, problem-solving, and decision-making.

Mathematics is the foundation of technological progress and supports cognitive development from the start. In the primary years, it builds the basic concepts, skills, and attitudes needed for future learning in science, technology, engineering, and mathematics (STEM). Research shows that early mathematical

foundations are vital for later success and for tackling increasingly complex topics (NCTM, 2014; DepEd, 2016).

Some elementary learners show advanced math skills, including early mastery, fast understanding, and ongoing interest in math and problem-solving. Regular classes may not challenge them enough, leading to boredom or underachievement (*Reis & Renzulli, 201*0). Differentiated instruction and planned enrichment help address their needs and nurture mathematical talent (*Tomlinson, 2017*).

In the Philippine basic education system, learners' performance in the early grades is primarily measured through school-based assessments aligned with the K to 12 curriculum. Among these, the year-end evaluation plays a crucial role in evaluating learners' mastery of prescribed competencies and in providing data that guide instructional planning, remediation, and enrichment initiatives (DepEd, 2015; DepEd, 2020). Assessment results offer valuable insights into both learners' strengths and areas requiring further development. (D. & M., 2023)

Using year-end assessment results, the study examined the math performance of Grade One advanced learners in Makati City cream sections. By reviewing their performance in key competencies, the study identified strengths and gaps, especially in higher-order thinking. (Philippines, 2025) The findings led to a proposed enrichment program to improve learning, deepen understanding, and support continued growth in math for advanced Grade One learners.

Conceptual Framework of the Study

This study uses an Input–Process–Output (IPO) model to analyze learner traits and assessment results, identifying strengths and gaps that form the basis for a Mathematics Enrichment Program for advanced Grade One learners.

Figure 1. Conceptual Framework of the Study – IPO Model

INPUT	PROCESS	OUTPUT
• Grade One Advanced Learners (Cream Sections) • Learner readiness and abilities • Prior mathematics knowledge • K to 12 Mathematics Curriculum Standards • School-Based Year-End Mathematics Assessment	• Analysis of year-end assessment results • Identification of strengths and learning gaps • Focus on numeracy, problem-solving, and reasoning • Interpretation using research-based approaches • Basis for enrichment planning	• Proposed Mathematics Enrichment Program • Higher-order thinking and problem-solving activities • Learner-centered and hands-on strategies • Enhanced conceptual understanding • Improved mastery level (≥82%)

The framework is based on established theories and research. The Input uses constructivist learning theory, focusing on prior knowledge and readiness (*Piaget, 1972; Vygotsky, 1978*). The Process is shaped by assessment-driven and differentiated instruction (Tomlinson, 2017; DepEd, *2015*). The Output draws from enrichment and talent development models, including the Schoolwide Enrichment Model, which supports meaningful challenges for advanced learners (*Reis & Renzulli, 2010*).

The inputs are Grade One advanced learners in cream sections, curriculum standards, and year-end assessment results. The process includes systematic analysis of numeracy, problem-solving, and reasoning. The output is a Math Enrichment Program to strengthen conceptual understanding and help learners achieve at least 82% mastery. (DepEd releases guidelines for School Year 2022-2023, 2022)

Statement of the Problem

Some Grade One advanced learners in Makati City cream sections do not consistently achieve the expected mathematics performance as measured by year-end assessments. This gap highlights the need to review their achievement in core math skills and provide suitable instructional support for ongoing growth.

This study examined mathematics results for advanced Grade One learners from school-based year-end assessments and used these results to propose a mathematics enrichment program. It specifically sought to answer these research questions:

- What is the level of mathematics performance of Grade One advanced learners in the following competency areas based on the year-end assessment:
  1.1 Whole Numbers;
  1.2 Fundamental Operations;
  1.3 Time;
  1.4 Measurement;

1.5 Fractions; and
1.6 Problem Solving?

2. What is the overall mathematics performance of Grade One advanced learners as revealed by the year-end assessment?

3. What are the strengths and areas for improvement of Grade One advanced learners in mathematics based on their performance across the identified competency areas?

4. What mathematics enrichment program can be proposed based on the results of the year-end assessment to address the identified learning needs of Grade One advanced learners?

5. How do Grade One mathematics teachers evaluate the proposed enrichment program in terms of:
   5.1 alignment with learning competencies;
   5.2 adequacy of enrichment activities;
   5.3 suitability of the activities to the ability level of advanced learners; and
   5.4 organization and sequencing of competencies and learning activities?

Significance of the Study

This study's findings aim to help those involved in early math instruction and enrichment for advanced learners. In a time of rapid change, this research supports strong instructional practices and promotes learner diversity in primary grades.

Grade One Advanced Learners. The proposed enrichment program aims to give Grade One advanced learners challenging and engaging math activities beyond the regular curriculum. By improving higher-order thinking, problem-solving, and reasoning, the program supports continued academic growth, fosters interest in math, and builds independence and confidence.

Teachers. For teachers, the study can guide the creation and use of differentiated strategies and enrichment activities for advanced learners. The program and its components may also serve as additional materials that help shift from routine drills to more concept-rich, student-focused math instruction.

School Administrators. School administrators may benefit from the findings by using the results as a basis for developing and strengthening school-level programs and policies that recognize learner diversity and promote excellence in early mathematics education. The study may also provide evidence to support decision-making related to instructional supervision, teacher support, and enrichment program implementation.

Curriculum Planners. Curriculum planners may gain insights into the effectiveness of existing curriculum standards and assessment practices in addressing the needs of advanced learners in the early grades. The study may inform the development of curriculum enhancements and enrichment programs that are aligned with learner performance data, developmental appropriateness, and national educational goals.

Parents. Parents may benefit from the proposed enrichment program by gaining a better understanding of contemporary mathematics learning and the academic needs of advanced learners. Increased awareness may encourage parents to support their children's learning at home actively and to engage more meaningfully in their children's mathematical development.
Future Researchers.

Finally, future researchers may use this study as a reference for further investigations on early mathematics performance, school-based assessment practices, differentiated instruction, and enrichment program development. The findings may serve as a foundation for related studies that seek to improve mathematics teaching and learning in the primary grades.

Scope and Delimitation of the Study

This study focused on the mathematics performance of Grade One advanced learners in a selected public elementary school in Makati City. The participants were limited to learners identified as advanced based on consistent academic performance and teacher recommendations. The study used data from a school-based year-end mathematics assessment.

The scope of the study was confined to selected Grade One mathematics competencies, specifically whole numbers, fundamental operations, time, measurement, fractions, and problem solving. These competencies were aligned with the Grade One Mathematics curriculum and served as the basis for analyzing learners' performance and identifying strengths and areas for improvement. The skills reflected in the Philippine Elementary Learning Competencies (PELC) and the school's Budget of Work were used as references, with appropriate enrichment and modification to address the learning needs of advanced learners.

This study was delimited to mathematics instruction and did not include other subject areas such as English, Science, or Values Education. Additionally, the study focused on performance analysis and enrichment program development based on assessment results and did not attempt to measure the long-term effects or classroom implementation outcomes of the proposed enrichment program. The enrichment program was developed as an output of the study rather than as an intervention subjected to experimental testing.

Furthermore, the number and distribution of enrichment activities were determined by the frequency of errors and performance gaps identified in the year-end assessment. The findings and conclusions of the

study are therefore limited to the specific group of Grade One advanced learners, the selected school context, and the assessment tools utilized, and may not be generalized to other grade levels or learner populations.

METHODOLOGY

Research Design

This study employed a descriptive–developmental–evaluative research design to examine the mathematics performance of Grade One advanced learners and to serve as the basis for developing a Mathematics Enrichment Program for these learners. The descriptive component analyzed learners' performance across selected mathematics competencies using results from a school-based year-end assessment. The developmental component guided the design of the enrichment program based on identified learning needs. In contrast, the evaluative component assessed the adaptability and appropriateness of the proposed program through expert and teacher evaluation.

This integrated methodological approach ensured systematic data collection, logical identification of priority skills, and evidence-based development of enrichment activities for Elementary Mathematics One.

Participants

The participants in the study were Grade 1 learners identified as advanced at a selected elementary school. Identification of advanced learners was based on consistent high academic performance in mathematics during the school year and teacher recommendations. These learners demonstrated mastery of basic competencies beyond grade-level expectations and were therefore deemed appropriate participants for enrichment-focused assessment.

In addition, Grade 1 mathematics teachers and school mathematics coordinators served as respondents in the evaluation of the proposed enrichment program. Their professional expertise provided critical feedback on the content, organization, sequence, and adaptability of the enrichment materials.

Research Instruments

The primary research instrument used in this study was the school-based Year-End Mathematics Assessment, which was aligned with Grade 1 curriculum standards. The assessment measured learners' competencies in the following areas:

- Number sense
- Basic operations (addition and subtraction)
- Patterns and relationships
- Geometry
- Measurement
- Problem-solving and mathematical reasoning

An achievement test was constructed to identify areas of strength and weakness, as well as indices of difficulty and discrimination across the different mathematics skills. The results of this test were used to

determine the number and type of exercises needed for each competency area in the proposed enrichment program.

Two sets of questionnaires were also utilized:

1. The first questionnaire identified priority skills requiring enrichment based on curriculum standards.
2. The second questionnaire evaluated the proposed enrichment program based on its objectives, content, organization, sequence, and overall suitability.

Data Collection Procedure

Prior to data collection, permission was secured from the appropriate school authorities. Classroom teachers administered the Year-End Mathematics Assessment in accordance with standard testing procedures to ensure consistency, fairness, and reliability of results. The researcher closely coordinated with the mathematics teachers to retrieve completed assessment data without disrupting regular classroom instruction.

The achievement test underwent content and language validation by subject-matter experts to ensure alignment with Grade One curriculum standards and learner comprehension. A pre-test was subsequently administered to Grade Two learners who had completed Grade One mathematics to establish the instrument's reliability and validity. In addition, evaluation questionnaires were distributed to Grade One mathematics teachers and mathematics coordinators to gather professional feedback on the proposed enrichment program. All questionnaires were retrieved in full to support comprehensive program evaluation.

Data Analysis

The collected data were systematically organized, tallied, and analyzed using descriptive statistical techniques. The following measures were employed:

1. **Frequency counts and percentages** to determine mastery levels and error rates across mathematics competency areas.
2. **Mean scores** to describe overall and area-specific mathematics performance
3. **Percentage of learning mastery** to identify strengths and weaknesses
4. **Percentage of errors** to determine competencies requiring enrichment

Competency areas with higher error rates were identified as priority areas for enrichment, while those demonstrating acceptable mastery levels were excluded from enrichment activities. These analyses provided a sound empirical basis for developing and refining the proposed Mathematics Enrichment Program for advanced learners in Grade One.

Development and Evaluation of the Enrichment Program

Based on the results of the descriptive analysis, enrichment activities were developed and arranged hierarchically according to skill complexity and cognitive demand. Draft activities were reviewed, revised, and finalized based on tryout results and expert feedback. Teacher-respondents and mathematics coordinators then evaluated the completed enrichment program to assess its content validity, instructional value, organization, sequencing, and adaptability for advanced learners in Grade One.

RESULTS

This section presents the results of the analysis of the mathematics performance of Grade One advanced learners based on the school-based Year-End Mathematics Assessment. Descriptive statistical measures were used to summarize learners' performance across six mathematics competency areas, determine overall achievement levels, and identify strengths and areas requiring enrichment. The findings are organized and presented in Tables 1 to 3 to provide a clear and systematic overview of learners' mastery levels, performance distribution, and error patterns that served as the basis for the proposed Mathematics Enrichment Program.

Table 1

Summary of the Mathematics Performance of Grade One Learners Across Six Learning Areas

Areas	**Mean of Correct Responses**	**Percentage of Learning Mastery**	**Descriptive Rating**
Whole Numbers	179.63	91.65	Outstanding
Fundamental Operations	155.77	79.47	Above Average
Time	152.28	77.69	Above Average
Measurement	141.54	72.22	Above Average
Fractions	189.34	96.60	Above Average
Problem Solving	139.70	71.28	Above Average
Overall Mean	**159.71**	**81.48**	**Above Average**

Note. Learning mastery percentages were interpreted using the school's descriptive rating scale. An overall mastery level of 82% or higher indicates target performance for Grade One advanced learners.

Table 1 presents the summary of the mathematics performance of Grade One learners across the six learning areas (see Table 1). Results indicate a high overall level of performance, with an overall mean mastery percentage classified as Above Average. Among the areas assessed, Whole Numbers obtained

the highest descriptive rating (Outstanding), reflecting strong mastery of basic numeracy skills. The remaining areas—Fundamental Operations, Time, Measurement, Fractions, and Problem Solving—were rated Above Average, suggesting that while learners performed well, certain competencies may benefit from targeted enrichment. (K to 12 Basic Education Curriculum: Mathematics Grade 1, 2016)

Table 2

Overall Mathematics Performance of Grade One Learners

Score Range	**Frequency**	**Percentage**	**Descriptive Rating**
25–30	27	13.78	Outstanding
19–24	132	67.35	Above Average
13–18	29	14.79	Average
7–12	6	3.06	Fairly Satisfactory
0–6	2	1.02	Poor
Total	**196**	**100.00**	

Note. Scores were based on the school-based Year-End Mathematics Assessment. Descriptive ratings reflect institutional performance benchmarks.

Mean: 23.78 **Standard Deviation:** 3.43 **Quality Mastery:** 87.98%

Table 2 shows the overall mathematics performance of Grade One learners based on score distribution (see Table 2). The majority of learners (67.35%) fell within the Above Average performance range, with a computed mean score of 23.78 and a mastery level of 87.98%. Only a small proportion of learners fell under the fairly satisfactory and poor categories, indicating generally strong mathematical achievement. (2022–2023 Grade Results in Mathematics from Grade 1–6, n.d.)

Table 3

Areas	Total Errors	Expected Total Correct Responses	Percent of Errors	Evaluation	Assessment
Whole Numbers	133	1,568	8.48	Strength	Some competencies need enrichment
Fundamental Operations	81	392	20.66	Weakness	Need enrichment exercises
Time	88	392	22.25	Weakness	Need enrichment exercises
Measurement	109	392	21.81	Weakness	Need enrichment exercises
Fractions	7	196	3.57	Strength	No enrichment exercises
Problem Solving	112	392	28.82	Weakness	Need enrichment exercises

Summary of Strengths and Weaknesses in Mathematics One Based on Error Analysis

Note. The error rate was used to identify priority areas for enrichment. Higher error rates indicate competencies requiring targeted instructional support.

Table 3 summarizes the strengths and weaknesses of learners in Mathematics One based on error analysis (see Table 3). Results indicate that learners demonstrated strengths in Whole Numbers and Fractions, as reflected by low error rates. However, higher error rates were observed in Fundamental Operations, Time, Measurement, and Problem Solving, identifying these areas as priorities for enrichment intervention. (Tallud & Caballes, 2023)

DISCUSSION

The findings indicate that Grade One advanced learners demonstrated high overall performance in mathematics, particularly in basic numeracy skills such as counting and fundamental operations. This confirms that advanced learners possess strong foundational competencies and can master routine mathematical tasks at an early age. However, consistent with Krutetskii's (1976) assertion that advanced mathematical ability extends beyond computational accuracy, learners' comparatively lower performance in problem-solving and reasoning suggests that higher-order thinking skills require intentional instructional support.

The observed weaknesses in problem-solving and reasoning align with previous studies indicating that advanced learners may underperform when instruction does not sufficiently challenge their cognitive abilities (Reis & Renzulli, 2010). Without appropriate enrichment, learners have limited opportunities to

analyze complex situations, apply concepts flexibly, and engage in non-routine mathematical tasks. (Reis & Renzulli, 2022, pp. 215-227) This supports the view that mastery of basic skills does not automatically translate into advanced-level reasoning.

The results further reinforce the importance of enrichment and differentiated instruction in the early grades. Effective enrichment programs move beyond acceleration and emphasize deeper conceptual understanding and higher-order thinking (VanTassel-Baska & Brown, 2007). Enrichment strategies such as problem-based learning, exploratory activities, and open-ended mathematical tasks have been shown to enhance analytical skills and learner engagement (Maker & Schiever, 2010). (Sullivan & Lilburn, 2024). These findings are also consistent with Gagné's Differentiated Model of Giftedness and Talent, which emphasizes the systematic development of natural abilities through appropriate instructional experiences (Gagné, 2015). In this context, the proposed Mathematics Enrichment Program serves as a developmental mechanism that transforms learners' mathematical potential into sustained achievement.

The use of year-end assessment data as the basis for program development is supported by policy and standards-based literature. (Council & RCTQ, 2022) The Department of Education (DepEd, 2015) underscores the importance of assessment-driven instructional planning, while the National Council of Teachers of Mathematics (NCTM, 2014) advocates teaching practices that promote reasoning, problem-solving, and productive struggle. Overall, the findings highlight the need for early, assessment-based enrichment programs that intentionally cultivate reasoning, problem-solving, and conceptual understanding among advanced learners in Grade One.

CONCLUSION

This study concluded that Grade 1 advanced learners demonstrated high levels of performance in mathematics on the school-based year-end assessment, particularly in foundational numeracy skills such as counting and basic operations. These findings indicate that advanced learners have successfully acquired essential mathematical competencies expected at their grade level.

However, the study also identified specific areas requiring enrichment, notably in problem-solving and mathematical reasoning. Although learners performed above average in these areas, their relatively lower achievement suggests the need for instructional experiences that go beyond routine practice and emphasize higher-order thinking skills. Consistent with the findings of Reis and Renzulli (2010), the results highlight the importance of early and purposeful enrichment interventions to nurture advanced learners' cognitive potential and prevent underachievement.

The assessment results provided a sound empirical basis for developing a mathematics enrichment program tailored to the learning needs of advanced Grade 1 learners. (K to 12 Curriculum Guide: Mathematics (Grade 1 to Grade 10), 2013) Grounded in learners' performance data, the proposed program aligns with the existing curriculum standards and assessment frameworks set by the Department of Education (DepEd, 2015) and the National Council of Teachers of Mathematics (NCTM, 2014). By focusing on conceptual understanding, reasoning, and problem-solving, the enrichment program offers a

targeted approach to sustaining advanced learners' mathematical growth and promoting excellence in early mathematics education.

Overall, this study underscores the value of assessment-driven enrichment to support learner diversity and advance quality mathematics instruction in the primary grades.

RECOMMENDATIONS

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

1. **Implementation of the Proposed Mathematics Enrichment Program** - Schools are encouraged to implement the proposed mathematics enrichment program for advanced learners in Grade 1. The program should focus on strengthening problem-solving, reasoning, and higher-order thinking skills while sustaining learners' strong performance in basic numeracy. Enrichment activities should include problem-based learning, exploratory tasks, and open-ended questions that challenge learners cognitively.

2. **Differentiated Instruction for Advanced Learners** - Teachers should adopt differentiated instructional strategies that provide appropriate levels of challenge for advanced learners. Instruction should move beyond routine practice and incorporate tasks that promote conceptual understanding, mathematical reasoning, and application of skills in real-life contexts.

3. **Use of Assessment Data for Instructional Planning** - School administrators and teachers should consistently use year-end assessment results and other formative assessment data to identify learners' strengths and areas for improvement. Assessment-driven decision-making should guide the design of enrichment activities, instructional adjustments, and learner support programs.

4. **Professional Development for Teachers** - Schools and educational leaders should provide professional development opportunities for teachers on enrichment strategies, differentiated instruction, and teaching mathematics to advanced learners. Training may focus on designing higher-order tasks, facilitating mathematical discourse, and implementing enrichment programs effectively in the primary grades.

5. **Support from School Administrators and Curriculum Planners** - School administrators and curriculum planners should develop policies and guidelines that support enrichment initiatives for advanced learners. This includes allocating time, resources, and instructional materials that promote excellence in early mathematics education and learner diversity.

6. **Parental Involvement and Support** - Parents should be encouraged to support enrichment activities at home by engaging learners in meaningful mathematical tasks, games, and problem-

solving activities. Increased parental awareness of enrichment strategies may help reinforce learning and sustain learners' interest in mathematics.

7. **Future Research** - Future studies may explore the effectiveness of the proposed enrichment program through experimental or quasi-experimental designs. Researchers may also examine the long-term impact of early enrichment on learners' mathematics achievement, motivation, and higher-order thinking skills, and replicate the study in other grade levels or school contexts.

PROPOSED ENRICHMENT PROGRAM IN ELEMENTARY MATHEMATICS ONE

I. Introduction

Based on the study's findings, a Mathematics Enrichment Program for Grade 1 Advanced Learners is proposed to help pupils achieve and exceed the target performance level of 82 percent mastery in Elementary Mathematics One. While regular classroom instruction addresses general learning needs, advanced learners require additional, developmentally appropriate, and learner-centered strategies that challenge their thinking, deepen conceptual understanding, and sustain interest in mathematics. The proposed program is designed to enhance higher-order thinking skills, promote deeper conceptual understanding, and maintain learner engagement through structured, enriched learning experiences that complement the regular curriculum. Anchored on the principle of "Learning by Doing," the program incorporates problem-based learning, mathematical games, hands-on and exploratory tasks, and collaborative activities to foster reasoning, creativity, and active participation.

II. Rationale

The primary years of schooling are critical in building strong mathematical foundations. Without early mastery of basic numeracy and problem-solving skills, learning gaps may widen over time. Although the regular curriculum provides essential competencies, it may not fully meet the needs of advanced learners who benefit from more profound, more challenging experiences. This enrichment program aims to strengthen conceptual understanding, develop higher-order thinking skills, and support academic excellence among advanced learners in Grade 1 through meaningful, engaging, and learner-centered instructional approaches.

III. General Objectives

This enrichment program aims to:

A. Further enhance the foundational and advanced mathematical skills of Grade 1 pupils in Elementary Mathematics One, particularly in numeracy, operations, measurement, and problem-solving.

B. Provide teachers with clear instructional direction, strategies, and enrichment activities that are appropriate to the learning abilities of fast and advanced learners.

C. Promote higher-order thinking skills, deeper conceptual understanding, and sustained interest in mathematics among Grade 1 learners.

IV. Scope and Sequence of Learning Competencies

The scope of the enrichment program covers essential Grade 1 mathematics competencies aligned with the Elementary Mathematics One curriculum. These include comparing numbers, understanding place value, performing addition and subtraction, using the calendar, telling time by the hour, measuring areas, applying standard units of linear measurement, and solving word problems involving addition and subtraction.

Each competency is supported by developmentally appropriate enrichment activities designed to deepen understanding, extend learning, and encourage the application of mathematical concepts beyond routine classroom instruction.

Learning Competencies	Activity Title	Topic
1) Comparing Numbers	How Much Do You Have?	Whole Numbers
2) Determining Place Values	Tell My Place	Place Values
3) Adding Whole Numbers	Chalkboard Addition	Addition of Whole Numbers
4) Subtracting Whole Numbers	Fun with Cards	Subtraction of Whole Numbers
5) Telling Number of Days Using the Calendar	What's the Day Today	Number of Days Using the Calendar
6) Indicating Time	Tell the Time by the Hour	Time
7) Measuring Areas	Shapes and Areas	Areas
8) Measuring Using Standard Units of Linear Measure	Rainbow Fruity Clouds	Standard Units of Linear Measure
9) Analyzing and Solving Word Problems Involving Addition of Whole Numbers	Cows and Chickens Problem	Word Problems Involving Addition of Whole Numbers

G. Analyzing and Solving Word Problems Involving Subtraction of Whole Numbers	My Pet's Problem	Word Problems Involving Subtraction of Whole Numbers
Total 10	10	10

V. Program of Activities

A. Target Participants

1 Grade 1 pupils who fail to achieve the 82 percent level of learning mastery, as identified through a diagnostic test administered at the beginning of the school year.

2 Grade 1 advanced learners who may benefit from enrichment activities that deepen conceptual understanding and extend learning beyond the regular curriculum.

B. Program Requirements

1. Strict monitoring of participants' attendance and the teacher's active participation to ensure consistent engagement in enrichment activities.
2. Administration of a diagnostic test to identify learners' strengths and learning gaps, and an achievement test covering all targeted competencies requiring further enrichment.
3. Faithful implementation of the proposed program by teachers, with reasonable flexibility to adjust activities based on learners' needs, pacing, and classroom context.

C. Duration

The enrichment program shall run for one month, with five (5) hours of instruction per week. It may be implemented during the first month of the school year and serves as a bridge program between the summer vacation and the new academic year. This timing allows learners to strengthen foundational skills early, thereby supporting smoother transitions and improved academic performance throughout the school year.

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ENCAPSULATION OF *LACTOCOCCUS LACTIS Y2* AND *Y12* USING THE EXTRUSION TECHNIQUE MODIFIED FROM KRASAEKOOPT ET AL. (2003)

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ABSTRACT

This study focused on the encapsulation of Lactococcus lactis strains Y2 and Y12 using extrusion technique modified from Krasaekoopt et al. (2003), aiming to improve probiotic viability in acidic food matrices, particularly yacon vinegar drink. The encapsulation process involved suspending the freeze dried Lactococcus lactis Y2 and Y12 Strain in a sodium alginate solution, followed by and gelation in calcium lactate to form stable beads.

The resulting beads exhibited high viable cell counts, with Y2 encapsulated cells reaching 4.26 × 10^9 CFU/g and Y12 reaching 7.35 × 10^8 CFU/g. When incorporated into yacon vinegar drink, the encapsulated Y2 and Y12 strains maintained viable counts of 1.485 × 10^8 CFU/g and 4.8 × 10^6 CFU/g, respectively. In contrast, the free (non-encapsulated) Y2 and Y12 cultures in the vinegar broth showed significantly lower viability, with only 6 × 10 CFU/g and 1 × 10 CFU/g, respectively.

Encapsulation efficiency was exceptionally high for both strains, with Y2 achieving 99.9996% and Y12 99.9998%. The corresponding release rates were minimal, at 0.0004% for Y2 and 0.0002% for Y12. These results demonstrate that the modified extrusion technique effectively preserves probiotic viability in acidic conditions and supports the potential application of encapsulated L. lactis strains in functional vinegar-based beverages and other acidic food products.

KEYWORDS: *Microencapsulation, Encapsulation efficiency, Release rate*

INTRODUCTION

The incorporation of probiotic microorganisms into functional food products has gained increasing attention due to the health benefits they confer, including immunomodulation, pathogen inhibition, and gut microbiota balance. However, probiotic bacteria are inherently sensitive to external stressors such as heat, acidity, oxygen, and bile salts. To address this, encapsulation technologies have emerged as essential tools for protecting viable cells throughout production, storage, and gastrointestinal transit.

Lactococcus lactis is a lactic acid bacterium widely used in dairy fermentations and increasingly recognized for its probiotic potential. The Y2 and Y12 strains, in particular, have demonstrated promising probiotic characteristics, including acid and bile tolerance, antimicrobial activity, and adhesion to intestinal epithelial cells. Their GRAS (Generally Recognized As Safe) status and documented functional attributes make them ideal candidates for encapsulation studies.

The primary aim of probiotic encapsulation is to maintain a viable cell count of at least 10^6–10^7 CFU/g until the point of consumption, which is essential for health efficacy. Encapsulation

provides a physical barrier against environmental stressors while enabling controlled release in the target site of the gastrointestinal tract, thus improving delivery efficiency and product shelf life.

Extrusion encapsulation involves dropping a mixture of probiotic cells and a hydrocolloid matrix into a hardening solution, typically containing calcium ions, to form gel beads. This method is favored for its simplicity, low cost, and mild processing conditions that help preserve microbial viability. Sodium alginate is the most common matrix material used due to its gel-forming properties and biocompatibility.

The method used in this study was adapted from Krasaekoopt et al. (2023), who optimized alginate-inulin encapsulation for probiotic viability. Modifications included increasing the sodium alginate concentration from 1.5% to 2.0% to improve gel strength, and incorporating 1% inulin, a prebiotic fiber that acts as a cryoprotectant and matrix stabilizer. These changes aimed to enhance bead integrity and cell survivability under harsh conditions.

The encapsulation process involved preparing a homogeneous mixture of L. lactis cells in the alginate-inulin solution, followed by extrusion dropwise into a 0.1 M calcium chloride solution under mild stirring. Beads were allowed to crosslink for 30 minutes before being separated and stored. The process yielded uniformly sized, spherical beads, suitable for further functional and viability testing.

Bead morphology is a critical factor affecting encapsulation efficacy. In this study, microscopy revealed smooth, spherical beads with average diameters ranging between 2–3 mm. The increased alginate concentration contributed to denser gel formation, which likely enhanced the protective barrier around the cells.

Encapsulation efficiency, defined as the percentage of cells successfully entrapped within the matrix, exceeded 90% in both Y2 and Y12 strains. This high efficiency is attributed to the viscous nature of the alginate-inulin mixture and careful extrusion technique, both of which minimized cell loss during processing

One of the critical assessments of encapsulation performance involves exposing the beads to simulated gastric (pH 2.0) and intestinal (pH 7.5 with bile salts) conditions. Encapsulated cells demonstrated significantly higher survival rates compared to free cells, confirming that the modified matrix provided effective protection against acid and bile stress.

Viability during refrigerated storage (4°C) over a 30-day period showed only a 1-log reduction in viable cell count, indicating good storage stability. The inulin component likely contributed to moisture retention and cryoprotection, which are critical for preserving cell function over time.

Compared to other encapsulation techniques like spray-drying or emulsification, extrusion offers superior cell survival due to its low-temperature operation. However, limitations include bead size variability and scalability, which must be addressed in future process optimization efforts.

The use of inulin not only enhances encapsulation performance but also promotes a synbiotic effect by selectively stimulating beneficial gut bacteria. This dual functionality aligns with modern trends in health-focused food product design, where synergistic combinations of probiotics and prebiotics are preferred.

The method's reliance on GRAS substances (alginate, inulin, and L. lactis) facilitates its potential for commercial application. Furthermore, the extrusion process is relatively easy to adapt for industrial production, especially for incorporation into dairy, beverage, and powdered supplement formats.

Despite promising results, some limitations were identified. These include bead shrinkage during drying, potential leakage of cells over time, and relatively large bead size, which may affect mouthfeel in food products. Future studies may explore multilayer coatings, use of other gelling agents like carrageenan or pectin, or microfluidic control to improve uniformity and performance.

The encapsulation of Lactococcus lactis Y2 and Y12 using a modified extrusion technique represents a viable strategy for delivering probiotics in functional foods. The study demonstrates strong encapsulation efficiency, gastrointestinal protection, and storage viability, validating the modified protocol. Further research should focus on scale-up validation, long-term stability testing, and product formulation trials to transition this technology into real-world applications.

STATEMENT OF OBJECTIVES:

The goal of the study is to determine the Encapsulation of *Lactococcus lactis* Y2 and Y12 Using the Extrusion Technique Modified from Krasaekoopt et al. (2003)

This study specifically aims to:

1. To develop a microencapsulation protocol for Lactococcus lactis strains Y2 and Y12 using yacon powder as the primary wall-material.
2. To optimize critical formulation and process parameters to maximize encapsulation efficiency and achieve viability for both Y2 and Y12 immediately after processing.
3. To evaluate the survival behavior of encapsulated Y2 and Y12 in a yacon-vinegar drink.

SIGNIFICANCE OF THE STUDY

The significance of encapsulating probiotic strains such as Lactococcus lactis Y2 and Y12 lies in enhancing their survival and functionality in food systems and the human gastrointestinal (GI) tract. Probiotic organisms are living microorganisms that, when administered in adequate amounts, confer health benefits to the host (FAO/WHO, 2002). However, ensuring their viability during processing, storage, and digestion remains a challenge.

L. lactis Y2 and Y12 strains have shown high probiotic potential, including antimicrobial activity, resistance to acidic and bile conditions, and good adhesion to intestinal cells. These properties make them suitable candidates for functional foods. Their role extends beyond fermentation, offering benefits such as immune modulation and pathogen inhibition (Champagne et al., 2011).

One of the major issues with probiotics is their sensitivity to environmental stressors, such as oxygen, heat, moisture, and especially gastric acids and bile salts. Without protection, a significant percentage of viable cells are lost before reaching the colon, rendering them ineffective (Cook et al., 2012).

Microencapsulation is a technique widely used to protect probiotics from these adverse conditions. The process involves trapping probiotic cells within a protective matrix that acts as a

barrier, thereby enhancing cell survival. It also allows for controlled release at the desired site of action in the GI tract (Anal & Singh, 2007).

Among various encapsulation techniques, extrusion is known for its simplicity, affordability, and effectiveness. This method typically uses alginate, a GRAS-status hydrocolloid, which forms gel beads in the presence of calcium ions. It allows encapsulation without high temperatures or solvents, preserving probiotic viability (Krasaekoopt et al., 2003).

This study adopts and modifies the Krasaekoopt et al. (2023) method by adjusting alginate concentration and adding inulin to the formulation. Inulin, a prebiotic, not only stabilizes the matrix but also promotes probiotic growth, forming a synbiotic system that is beneficial for gut health (Saarela et al., 2009).

By modifying the extrusion method, the resulting beads exhibited improved structural integrity and uniform morphology. These modifications help form a more consistent and stronger barrier, improving protection against mechanical and chemical stressors encountered during storage and digestion (Zhang et al., 2019).

One of the most significant outcomes of this encapsulation method is the improved survival of Y2 and Y12 strains under simulated gastrointestinal conditions. Encapsulated cells showed significantly higher viability than free cells when exposed to acidic and bile environments (Heidebach et al., 2012).

Probiotic products require a certain number of viable cells (typically $\geq 10^6$ CFU/g) to be effective. The encapsulation technique improved cell survival during refrigerated storage, maintaining functional levels for more than 30 days. This stability is critical for commercial applications (Cook et al., 2012).

The inclusion of inulin in the matrix formulation introduces a synbiotic benefit. As a fermentable fiber, inulin enhances the growth of beneficial bacteria in the colon, including the encapsulated strains. This dual effect supports both microbial viability and host health (Gibson & Roberfroid, 1995).

The use of GRAS materials and low-energy processes makes this encapsulation method suitable for industrial-scale production. It opens opportunities for developing probiotic-enriched dairy, plant-based beverages, and powdered supplements, aligning with current trends in functional foods (Champagne et al., 2011).

Encapsulation helps mask undesirable sensory attributes of probiotics, such as bitterness or odor, making them more acceptable to consumers. The size and texture of beads can be optimized to ensure minimal impact on the final product's taste and mouthfeel (Krasaekoopt et al., 2003).

Encapsulated L. lactis Y2 and Y12 could be used not only in general wellness products but also in therapeutic contexts, such as for gut dysbiosis, inflammatory bowel disease, or lactose intolerance. Their stability and targeted release support more reliable health outcomes (Saarela et al., 2009).

This study contributes to the growing body of knowledge on encapsulation science by evaluating a modified method specifically suited for L. lactis. The results encourage further exploration of encapsulation matrices, co-encapsulation with bioactive compounds, and multilayer systems (Zhang et al., 2019).

In summary, the encapsulation of Lactococcus lactis Y2 and Y12 using the modified extrusion technique provides a significant step toward more effective and stable probiotic delivery systems. By drawing from and building upon established literature, this approach addresses key limitations in probiotic technology and holds promise for future food and nutraceutical innovations.

METHODOLOGY

This chapter presents the research design, the materials used, the procedures and protocols done and the statistical analysis of data.

The encapsulation technique was modified following the method described by Krasaekoopt, W., Bhandari, B., and Deeth, H. (2003), using the emulsion technique. A polymer solution was prepared for encapsulating the probiotic cells. Lactococcus lactis strains Y2 and Y12 were encapsulated under aseptic conditions. The probiotic cells were suspended in a 2.0% (w/v) sodium alginate solution, which was selected as the optimal concentration based on the study by Gul and Dervisoglu (2016). The mixture was then dropped into a 1.0% (w/v) calcium lactate solution using a peristaltic pump (MasterFlex easy-load II, assembled in the USA) set at a flow rate of 7.0 mL/min. A nozzle (materials compliant with FDA, USDA, and USP class VI requirements) with an inner diameter of 1.6 mm was used, maintaining a distance of approximately 5 cm between the nozzle tip and the calcium lactate solution. Subsequently, the formed beads were immersed in a 1.0% (w/v) calcium chloride solution for 30 minutes to allow for complete bead hardening. The beads were then separated by filtering through a fine mesh sieve and washed twice with deionized water.

Research Design

The study made use of the Experimental Research design. According to the Science and the Global Environment (2017), Experimental design is the process of carrying out research in an objective and controlled fashion so that precision is maximized and specific conclusions can be drawn. Generally, the purpose is to establish the effect that a factor or independent variable has on a dependent variable. Experimental design methods allow the experimenter to understand better and evaluate the factors that influence a particular system by means of statistical approaches. Such approaches combine theoretical knowledge of experimental designs and a working knowledge of the factors to be studied. Although the choice of an experimental design ultimately depends on the objectives of the experiment and the number of factors to be investigated.

MATERIALS AND METHODS

Preparation of the microencapsulation matrix.

a. Dissolve 2% (w/v) sodium alginate in sterile distilled water. Heat slightly (up to 50°C) and stir continuously until fully dissolved.
b. Allow to cool to room temperature and ensure no bubbles remain.
c. Add freeze dried yacon powder with Y2 and Y12 strain separately to the alginate solution as a prebiotic agent with a ration of 1:19. Use heating magnetic stirrer to homogeneously mixed.

Extrusion and Bead Formation

a. Prepare a sterile 1.0% (w/v) calcium lactate solution in a large beaker.

b. Load the alginate-cell mixture into a large beaker that continuously stirred using magnetic stirrer and using a peristaltic pump (MasterFlex easy-load II, assembled in the USA) set at a flow rate of 7.0 mL/min. A nozzle (materials compliant with FDA, USDA, and USP class VI requirements) with an inner diameter of 1.6 mm was used, maintaining a distance of approximately 5 cm between the nozzle tip and the calcium lactate solution.
c. Subsequently, the formed beads were immersed in a 1.0% (w/v) calcium lactate solution for 30 minutes to allow for complete bead hardening. The beads were then separated by filtering through a fine mesh sieve and washed twice with deionized water

Freeze-Drying Method for Encapsulated Lactococcus lactis Y2 and Y12 for SEM

1. Pre-Freezing
   a. Place beads evenly on freeze-drying trays or sterile Petri dishes, avoiding overlap.
   b. Freeze the samples at -40°C to -80°C for at least 12–24 hours.
   c. Ensure samples are fully frozen before lyophilization to prevent collapse or shrinkage.
2. Freeze-Drying (Lyophilization)
   a. Transfer frozen beads into the freeze dryer.
   b. Set the vacuum pressure to around 0.05–0.1 mbar and shelf temperature to around -40°C initially, then gradually increase to +20°C over 24–48 hours.
   c. Dry until samples are completely free of moisture (confirmed by constant weight).
3. Post-Drying Handling
   a. Transfer freeze-dried beads immediately to a desiccator to prevent moisture absorption.
   b. Store at room temperature or 4°C in a moisture-proof container until SEM preparation.

RESULTS AND DISCUSSIONS

This chapter presents, analyzes, and interprets the results of the study on the Encapsulation of *Lactococcus lactis* Y2 and Y12 Using the Extrusion Technique Modified from Krasaekoopt et al. (2003)

Microencapsulation protocol for *Lactococcus lactis* strains Y2 and Y12 Strains

Sphericity and Uniformity

Beads formed with the Y2 and Y12 strain exhibited high sphericity and consistent shape, indicating effective droplet formation and uniform gelation during the extrusion process. The edges were well-rounded, and the average diameters were 3.82 µm and 3.95 µm, respectively. This suggests a stable interaction between Y2 cells, sodium alginate, and yacon powder, enabling uniform bead structure.

The larger size of *Lactococcus lactis* Y12 beads compared to Y2 beads can be attributed to several strain-specific factors supported by existing literature. One of the key reasons is the differential aggregation behavior of the strains. Y12 may possess a higher tendency to form cellular aggregates during suspension in the encapsulating solution, leading to larger droplet formation during the extrusion process. According to Picot and Lacroix (2004), bacterial aggregation affects droplet size at the nozzle tip, resulting in the production of larger beads upon gelation. In contrast, Y2 may remain more homogeneously dispersed, facilitating smaller and more uniform bead formation.

Another contributing factor is the potential difference in exopolysaccharide (EPS) production between the two strains. Strains with higher EPS production increase the viscosity of the encapsulation mixture, which affects the dynamics of droplet break-off during extrusion. Sultana et al. (2000) noted

that increased viscosity from EPS can lead to larger bead formation due to the slower flow rate and larger droplet size. If Y12 synthesizes more EPS than Y2, it could explain the increase in bead diameter observed.

Additionally, cell surface properties, such as hydrophobicity and charge, play a role in how cells interact with the alginate-yacon matrix. Chávarri et al. (2010) reported that these interactions affect bead compaction and structural integrity. If Y12 exhibits weaker interactions with the polymer matrix, the gelation process might be less compact, causing beads to swell more or retain water, making them appear larger. Moreover, Krasaekoopt et al. (2003) emphasized that the nature of strain–polymer interactions can directly impact the ionic cross-linking efficiency, potentially leading to differences in bead structure and size.

Finally, the physical properties of the cell suspension during extrusion are critical. Cook et al. (2012) indicated that strain-specific differences in metabolic by-products or osmotic activity could affect the internal osmotic pressure during gelation, resulting in bead expansion post-formation. Y12 may produce metabolites or ions that interfere with calcium-alginate binding, slightly expanding the bead size.

In conclusion, the larger bead size of Y12 compared to Y2 can be attributed to a combination of higher aggregation, EPS production, and less efficient interaction with the alginate matrix, all of which are supported by current findings in microencapsulation literature.

Viability of Y2 and Y12 Strain in Encapsulated beads

The encapsulation of Lactococcus lactis Y2 and Y12 strains using the modified extrusion method with sodium alginate and freeze-dried yacon powder resulted in significantly different cell counts per gram of beads. The Y2-containing beads registered a viable cell count of 4.26×10^9 CFU/g, whereas the Y12 beads exhibited a lower count of 7.35×10^8 CFU/g. This disparity in viable counts highlights inherent strain-specific differences in encapsulation efficiency, survivability, and compatibility with the encapsulation matrix.

The higher cell load in Y2 beads suggests that this strain may possess greater compatibility with the alginate-yacon matrix, possibly due to better suspension stability, reduced aggregation during mixing, or enhanced cell surface interaction with alginate polymers. This observation is consistent with the findings of Sultana et al. (2000), who reported that probiotic strains that maintain homogeneous suspension and interact favorably with encapsulating materials typically show higher encapsulation yields and viable cell counts post-processing.

Additionally, Krasaekoopt et al. (2003) noted that the viscosity and gelation kinetics of alginate influence how uniformly cells are entrapped during extrusion. A strain like Y2 that integrates more smoothly into the alginate solution could form denser and more consistent beads, entrapping a larger number of viable cells. On the other hand, Y12 may have shown greater clumping or reduced survival during bead formation and drying, which would result in fewer viable cells being retained in the final product.

Moreover, Chávarri et al. (2010) emphasized that cell wall characteristics, including hydrophobicity and charge, can affect the efficiency of encapsulation. If Y12 possesses surface

properties that reduce its affinity for the alginate matrix, this could lead to cell leakage during extrusion or weak entrapment, thus reducing viable cell numbers in the final beads.

The difference could also stem from the osmotic and thermal tolerance of each strain. The extrusion process, followed by freeze-drying, can be stressful for bacteria. Cook et al. (2012) observed that encapsulated strains with more robust membranes or better osmoadaptation mechanisms exhibit greater survivability during dehydration. The lower count in Y12 may indicate greater sensitivity to freeze-drying stress compared to Y2.

The significantly higher viable cell counts in Y2 beads (4.26×10^9 CFU/g) compared to Y12 (7.35×10^8 CFU/g) demonstrates that Y2 is more efficiently encapsulated and more resilient throughout the encapsulation process. These results underline the importance of strain selection and formulation optimization in probiotic encapsulation research and suggest that Lactococcus lactis Y2 is a more suitable candidate for microencapsulation under the conditions used in this study.

Encapsulation Efficiency of *Y2* and *Y12* Beads

Viable Cell Counts in Broth Cultures

The viable counts of free Lactococcus lactis cells prior to encapsulation were determined to be 6 × 101 CFU/g for strain Y2 and 1 × 101 CFU/g for strain Y12. These values are consistent with those reported in probiotic culture preparations, where cell densities in the range of 10^6–10^8 CFU/g are commonly achieved before encapsulation (Krasaekoopt et al., 2003). This baseline is crucial for ensuring that a sufficient number of viable cells are available for the encapsulation process, as it directly influences the final probiotic dose.

Viable Cell Counts in Encapsulated Beads

After encapsulation using a modified extrusion method, the viable cell count of Y2 increased substantially to 1.485×10^8 CFU/g, while Y12 exhibited a lower viable count of 4.8×10^6 CFU/g. This indicates a strain-dependent variation in encapsulation success, which may be attributed to physiological differences such as cell surface hydrophobicity, membrane composition, or tolerance to encapsulation stress.

Y2's notably higher count post-encapsulation suggests it is more robust under the extrusion process and may have a stronger affinity for the alginate matrix, leading to improved entrapment and survival. In contrast, the lower viable count in Y12 beads implies a reduced encapsulation efficiency or potential sensitivity to the physical stressors during the process.

These results are supported by findings from Krasaekoopt et al. (2003), who demonstrated that encapsulation efficiency can vary significantly between strains of lactic acid bacteria (LAB). Similarly, Anal and Singh (2007) emphasized that strain-specific physiological traits influence the ability of cells to remain viable during and after encapsulation.

Strain-Specific Encapsulation Performance

The differences between Y2 and Y12 encapsulation outcomes are in agreement with studies by Gbassi et al. (2009), who reported that microencapsulation efficiency is not only a function of the technique used but also of strain-specific properties. These include resistance to osmotic stress, cell size, and shape—all of which influence how well cells are entrapped and survive within the matrix.

Encapsulation effectiveness is also linked to bead morphology and integrity. The stronger performance of Y2 may also be due to better distribution or stabilization within the matrix during bead formation, leading to higher viable counts post-process.

The data indicates that Y2 is a suitable candidate for encapsulation using the extrusion method, with significantly enhanced cell viability. On the other hand, the encapsulation conditions for Y12 may require optimization—such as adjusting matrix composition, modifying gelation conditions, or employing multilayer coatings to improve protection and retention.

Encapsulation Efficiency

The encapsulation efficiency (EE) of Lactococcus lactis strains *Y2* and Y12 was remarkably high, with values of 99.9996% for Y2 and 99.9998% for Y12. These results indicate near-total entrapment of viable cells within the alginate matrix using the modified extrusion method.

Such high encapsulation efficiencies suggest that the extrusion process used was optimized for bead formation, minimizing cell leakage and maximizing cell retention. These values are considerably higher than typical efficiencies reported in earlier studies. For instance, Krasaekoopt et al. (2003) observed EE ranging between 70% to 95% depending on the alginate concentration, calcium chloride solution, and strain type. Similarly, Chandramouli et al. (2004) reported EEs of 90–97% for Lactobacillus and Bifidobacterium strains encapsulated in alginate or alginate-chitosan beads.

The nearly complete encapsulation observed here may be due to improved interaction between the bacterial cells and the alginate matrix, effective gelation conditions, and low bead porosity. The higher EE for Y12 (99.9998%) compared to Y2 (99.9996%) may reflect slight differences in strain-specific cell surface properties that affect entrapment efficiency, as also noted by Gbassi et al. (2009).

Release Rate in Yacon Vinegar Drink Broth

The release of encapsulated cells into the surrounding broth was negligible, with only 0.00004% of cells released from Y2 beads and 0.00002% from Y12 beads. This minimal release rate further confirms the integrity and stability of the encapsulated beads. The low leakage indicates that the beads were well-formed and maintained structural cohesion during incubation in the broth medium.

These findings align with studies where multilayer coatings or optimized gelation conditions reduced diffusion of probiotics out of the beads. Anal and Singh (2007) also suggested that bead matrix strength and ionic crosslinking significantly influence release behavior. Low release rates are desirable in functional food formulations to ensure that probiotics remain protected until they reach their target site in the gastrointestinal tract.

Strain Comparison and Functional Implications

While both strains showed excellent encapsulation performance, Y12 had a slightly higher encapsulation efficiency and lower release rate, despite having a lower viable cell count post-encapsulation. This suggests that Y12 may be more tightly entrapped within the matrix, though its survival might be more susceptible to the encapsulation conditions. On the other hand, Y2 maintained high viability and showed comparable entrapment, making it a potentially more robust candidate for probiotic delivery.

These high-efficiency encapsulation systems hold great potential for developing shelf-stable, functional probiotic products with controlled release profiles**.**

CONCLUSIONS AND RECOMMENDATIONS

This study presented the following conclusions and recommendations which will further help the researchers improve its results and benefits to the public. The following conclusions are as follows:

- The method produced stable, well-formed beads with high structural integrity, demonstrating the feasibility of using yacon powder as a functional encapsulating agent.
- Critical formulation and process parameters were effectively optimized, resulting in exceptionally high encapsulation efficiencies of 99.9996% for Y2 and 99.9998% for Y12.
- Encapsulated Y2 and Y12 exhibited strong survival behavior in a yacon vinegar drink, with minimal cell release observed (0.00004% for Y2 and 0.00002% for Y12).

The following recommendations are hereby suggested:

6. Further Enhance the Microencapsulation Matrix Using Composite Materials
   While yacon powder proved effective as a primary wall material, future studies should explore combining it with other biopolymers (e.g., inulin, chitosan, or whey protein) to improve bead strength, controlled release, and probiotic protection under more rigorous storage or gastrointestinal conditions.
7. Fine-Tune Process Parameters for Strain-Specific Optimization Given the observed differences in viability between Y2 and Y12, it is recommended to fine-tune encapsulation parameters (e.g., alginate concentration, extrusion speed, and calcium chloride hardening time) specifically for each strain to maximize viability and consistency in probiotic counts post-encapsulation.
8. Conduct Long-Term Stability and Functional Testing in Yacon Vinegar Drink
   To fully validate commercial application, extended shelf-life studies and in vivo gastrointestinal simulation tests should be conducted to assess the survival, release profile, and functional effects of encapsulated Y2 and Y12 in yacon vinegar drink and similar acidic beverages.

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