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SEC Registration No.: 2024020137294-00
Sta. Ana, Pampanga, Philippines
Website: https://etcor.org
iJOINED ETCOR
P - ISSN 2984-7567
E - ISSN 2945-3577
The Exigency
P - ISSN 2984-7842
E - ISSN 1908-3181

Brain-based Mathematics toolkit for integers

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Received: 08 October 2025 **Revised**: 19 December 2025 **Accepted**: 26 December 2025

Available Online: 27 December 2025

Volume IV (2025), Issue 4, P-ISSN – 2984-7567; E-ISSN - 2945-3577

https://doi.org/10.63498/etcor523

Abstract
Aim: This study developed and evaluated a brain-based mathematics toolkit for integers as a remediation tool to improve learners' performance in fundamental integer operations at Lezo Integrated School. It examined the toolkit's acceptability and explored learners' experiences of its effectiveness and use.
Methodology: A mixed-methods educational design research using the ADDIE model was employed. Participants were 60 secondary learners purposively selected from those who scored "low" or "not proficient" on the E-RUNT pretest. Instruments included the DepEd Evaluation Rating Sheet for Non-Print Materials and semi-structured interview guides validated by experts. The toolkit was implemented for one week; quantitative data were analyzed using frequency counts, percentages, means, and standard deviations, and qualitative data were analyzed using thematic analysis.
Results: Expert and learner evaluations rated the toolkit as highly acceptable across content, instructional, and technical quality (overall mean ≈ 3.9/4.0). Numeracy outcomes improved: the proportion of junior high learners classified as low/not proficient decreased from 13.71% (pretest) to 2.54% (posttest), and senior high decreased from 5.50% to 0%. Learner interviews described the toolkit as cognitively engaging, affectively safe, and effective for remediation.
Conclusion: The brain-based mathematics toolkit for integers is an acceptable and effective remediation resource for improving learners' numeracy in integer operations. Wider adoption and further longitudinal evaluation are recommended.
Keywords: *mathematics toolkit; brain-based learning; remediation; integers; mixed-methods*

INTRODUCTION

Recent international assessments underscore persistent challenges in mathematical literacy worldwide. Reports from United Nations Educational, Scientific and Cultural Organization (2022) revealed that despite global efforts to improve numeracy, many learners continued to struggle with foundational mathematical skills. These global trends have been mirrored in the Philippine context. The 2019 Trends in International Mathematics and Science Study (TIMSS) revealed that the Philippines ranked last among 58 participating countries, with an average scale score of only 297—pointedly below the international benchmark. More recent learning recovery reports from the Department of Education confirmed that Filipino learners continued to face substantial gaps in numeracy, particularly in mastering basic mathematical operations.

This national crisis is reflected at the local level. At Lezo Integrated School, results of the Enhanced Regional Unified Numeracy Test (E-RUNT) Pretest conducted in September 2024 showed that 9.9% (39 learners) of the 394 junior high school learners were low proficient and 3.81% (15 learners) were not proficient. Among 109 senior high school learners, 5.5% (6 learners) were low proficient. Low proficient learners scored 10–19, while not proficient learners scored 0–9 out of the 40-item test. These findings emphasize the urgent need for targeted interventions to strengthen learners' numeracy skills, particularly in fundamental operations with integers.

One promising approach is the use of a mathematics toolkit, a structured set of pedagogical resources such as manipulatives, visual aids, graphic organizers, songs, worksheets, and strategic prompts designed to support conceptual understanding and procedural fluency. Recent studies (Gomez & Suarez, 2020; Gari & Malonisio, 2023; Slamet et al., 2021; Tambong & Malonisio, 2025) affirm that toolkits aligned with inquiry-based and equity-driven models enhance learner engagement and reduce math anxiety. More recent empirical research has expanded this

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evidence base, demonstrating the effectiveness of intervention materials and brain-based instructional strategies in improving numeracy outcomes across diverse contexts.

Brain-based learning theory, grounded in neuroscience, emphasizes teaching strategies that align with how the brain naturally learns. Caine and Caine (1994) and Jensen (2008) highlight three core principles—relaxed alertness, orchestrated immersion, and active processing—that foster cognitive engagement and deeper understanding. In this study, these principles guided the design of the mathematics toolkit for integers, ensuring activities were stimulating, emotionally safe, and effective for remediation. Prior research (Olaoluwa, 2024; Sari et al., 2023) confirmed the benefits of brain-based strategies in improving performance and creative thinking. However, no study has yet developed a toolkit specifically for integer operations, evaluated its acceptability using DepEd's rating sheet, or explored learner experiences based on E-RUNT outcomes.

This study addresses these gaps by developing and evaluating a brain-based mathematics toolkit for integers as a remediation tool, determining its acceptability, and exploring learners' experiences of its effectiveness and utilization. The toolkit contributes to educational innovation by integrating songs, puzzles, and manipulatives within an ADDIE-based design framework. It advances remediation practices by directly targeting learners identified as low or non-proficient in E-RUNT. It also enriches neuroscience-informed pedagogy by operationalizing brain-based principles in a structured toolkit format.

This study offers academic significance for mathematics education in the Philippines. It provides a novel model of intervention that bridges global pedagogical trends, national numeracy challenges, and local school realities. By situating toolkit design within brain-based learning theory, the research not only addresses immediate remediation needs but also contributes to the broader discourse on sustainable, theory-driven innovations in mathematics instruction.

Review of Related Literature

This section synthesizes current literature pertinent to the study of Brain-Based Mathematics Toolkit for Integers and its impact on enhancing the numeracy skills of learners at Lezo Integrated School. The review encompasses global and Philippine contexts, focusing on mathematics toolkit, numeracy challenges, and the application of Brain-Based Learning Theory in educational settings.

Global assessments continue to highlight persistent gaps in mathematical literacy. UNESCO (2022) reported widespread difficulties in foundational numeracy, findings echoed in the Philippines where TIMSS 2019 ranked the country last among 58 participants. Local assessments such as the Enhanced Regional Unified Numeracy Test (E-RUNT) further confirm deficits in integer operations among secondary learners.

Instructional toolkits have emerged as promising interventions. Studies affirm that structured pedagogical resources such as manipulatives, puzzles, songs, and graphic organizers enhance engagement and reduce math anxiety (Gomez & Suarez, 2020; Gari & Malonisio, 2023; Slamet et al., 2021; Tambong & Malonisio, 2025). Brain-based learning theory strengthens this approach by aligning instruction with how the brain processes information. Caine and Caine (1994) and Jensen (2008) emphasize relaxed alertness, orchestrated immersion, and active processing as principles that optimize cognitive engagement. Empirical evidence supports these claims: Amjada et al. (2023) and Olaoluwa (2024) demonstrated improved mathematical performance through brain-based strategies, while Sari et al. (2023) showed enhanced creative thinking in trigonometry. Philippine studies likewise affirm the effectiveness of brain-based learning in improving conceptual understanding (Funa et al., 2024).

Complementary to this, Cognitive Load Theory (Sweller, 1988; Van Merrienboer & Sweller, 2005) explains how instructional materials can optimize working memory by reducing extraneous load and scaffolding essential concepts. This perspective has informed the design of strategic intervention materials (Quigley, 2019; Udofia & Ibok, 2025), highlighting the importance of structured, multimodal formats for remediation.

Despite these advances, gaps remain. No prior study has developed a brain-based mathematics toolkit specifically for integer operations, nor evaluated its acceptability using the Department of Education's Evaluation Rating Sheet for Non-Print Materials (DepEd, 2022). Furthermore, learner experiences with toolkit use in the Philippine context, particularly those identified as low or not proficient in E-RUNT, have not been systematically documented. Addressing these gaps situates the present study within the broader discourse on neuroscience-informed pedagogy and evidence-based remediation.

Theoretical Framework

This study is anchored on Brain-Based Learning Theory (Caine & Caine, 1994), which asserts that effective teaching aligns with how the brain naturally processes information. Its core principles relaxed alertness, orchestrated

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immersion, and active processing guide the design of the Brain-Based Mathematics Toolkit for Integers, fostering cognitive engagement, emotional safety, and meaningful remediation to strengthen learners' mastery of integer operations. Furthermore, Cognitive Load Theory (Sweller, 1988) explains how instructional materials affect learning by recognizing the limits of working memory. To avoid overload and enhance processing, instructional design must reduce extraneous demands while emphasizing essential concepts (Van Merrienboer & Sweller, 2005). In this study, the toolkit applies these principles by presenting integer operations in structured, scaffolded, and multimodal formats, thereby optimizing working memory and improving numeracy outcomes.

Conceptual Framework

The study illustrates the relationship between the Brain-Based Mathematics Toolkit for Integers and learners' numeracy outcomes through three components:

1. **Input:** Refers to the learners' baseline performance in integer operations, measured through the Enhanced Regional Unified Numeracy Test (E-RUNT) Pretest Results.
2. **Process/Intervention:** Refers to the design, development, implementation, and evaluation of the toolkit, guided by brain-based learning principles and assessed using DepEd's standards for non-print materials.
3. **Output/Outcome:** Refers to an enhanced Brain-Based Mathematics Toolkit for Integers, validated for quality and effectiveness, leading to improved mastery of integer operations and positive learner experiences.

[Input: Enhanced Regional Unified Numeracy Test (E-RUNT) Pretest Results]
↓
[Process: Design, Development, Implementation, and Evaluation of the Brain-Based Mathematics Toolkit for Integers]
↓
[Output: Enhanced Brain-Based Mathematics Toolkit for Integers]

The framework shows that learners' baseline performance in integer operations, measured by the E-RUNT Pretest, guides the design, development, implementation, and evaluation of the Brain-Based Mathematics Toolkit for Integers. Grounded in brain-based learning principles and cognitive load theory, the intervention produces a validated toolkit that enhances mastery of integer operations and strengthens learner engagement in numeracy.

Statement of the Problem

Numeracy deficits among Filipino learners remain a pressing educational challenge, as indicated by both national and local assessments. Despite the availability of instructional materials, there is limited evidence on the effectiveness of remediation tools that integrate brain-based learning principles, particularly in the teaching of integers—a foundational yet commonly difficult topic for secondary students. Existing studies have explored mathematics toolkits and brain-based strategies independently; however, few investigations have combined these approaches in the development of a context-specific remediation material tailored to learners with low performance in the Enhanced Regional Unified Numeracy Test (E-RUNT). Moreover, there is a lack of research evaluating the acceptability of such materials using standardized DepEd quality assurance tools and documenting learners' experiences in their actual implementation. Addressing these gaps is essential to support improved numeracy outcomes and inform the design of pedagogically sound intervention materials for struggling learners.

Research Objectives

The primary objective of this study was to develop and evaluate a brain-based mathematics toolkit for integers as a remediation tool for secondary learners.

Specifically, the study aimed:

1. To determine the level of acceptability of the developed brain-based mathematics toolkit for integers in terms of:
   a) content quality,
   b) instructional quality,
   c) technical quality, and
   d) other findings as evaluated by experts and learners.

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2. To explore the learners' experiences in using the brain-based mathematics toolkit for integers.
3. To formulate recommendations based on the results of the evaluation and learners' experiences.

Research Questions

To address the foregoing objectives, the following questions guided the conduct of the study:

1. What is the level of acceptability of the developed brain-based mathematics toolkit for integers in terms of:
   a) content quality,
   b) instructional quality,
   c) technical quality, and
   d) other findings as evaluated by experts and learners?
2. What are the experiences of the learners in using the brain-based mathematics toolkit for integers?
3. What recommendations may be offered based on the results of the study?

METHODS

Research Design

This study employed educational design research (EDR) using the ADDIE Model (Analysis, Design, Development, Implementation, Evaluation), a systematic framework that bridges theory and practice in instructional material development (Quigley, 2019). Learners' numeracy difficulties from the E-RUNT Pretest informed the Analysis phase, while toolkit components—manipulatives, songs, puzzles, and worksheets—were designed and developed following brain-based learning principles. Implementation involved classroom use with low-proficient learners, and Evaluation assessed effectiveness through performance scores, DepEd's Evaluation Rating Sheet, and learner feedback.

A mixed-methods approach integrated quantitative data such as scores and ratings and qualitative insights from interviews and reflections ensuring both rigor and contextual depth.

Population and Sampling

The participants of the research were the identified 60 secondary learners having low and not proficient scores on the Enhanced Regional Unified Numeracy Test (E-RUNT) Pretest results, indicating a need for improvement in their numeracy skills at Lezo Integrated School, Lezo District, Schools Division of Aklan. The respondents were selected through purposive sampling based on their scores on ERUNT Pretest conducted in September 2024.

For the qualitative phase, five learners were chosen from the same group to participate in interviews. The smaller sample size was justified because qualitative inquiry seeks depth rather than breadth; interviewing a focused subset allowed for a detailed exploration of learner experiences, perceptions, and engagement with the brain-based mathematics toolkit.

Instrument

The Evaluation Rating Sheet for Non-Print Materials, prescribed in DepEd Division Memorandum No. 343, s. 2022, was used as the quantitative instrument to assess the acceptability of the brain-based mathematics toolkit for integers in terms of content accuracy, instructional design, presentation, and usability. Its reliability and validity were established through DepEd's prior validation and official adoption for quality assurance.

For the qualitative phase, interview guides explored learners' experiences, focusing on motivation, ease of use, and effectiveness in improving integer operations. Sample questions asked how the toolkit aided understanding and which components were most engaging. To ensure validity, the guides were reviewed by three experts in mathematics education and instructional design.

Data Collection

Data collection for the quantitative phase took place at Lezo Integrated School in February 2025. The process began after the development of the brain-based mathematics toolkit for integers. The toolkit was implemented with the 60 purposively selected secondary learners over a one-week period. During and after implementation, quantitative data were gathered through the Evaluation Rating Sheet for Non-Print Materials prescribed by the Department of Education. This instrument measured the toolkit's acceptability and quality across constructs such as content accuracy, instructional design, presentation, and usability. Scores from the rating sheet provided numerical evidence of the toolkit's effectiveness and appropriateness.

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Qualitative data were collected concurrently during the same implementation period. A subset of five learners was selected from the participant group to provide in-depth insights into their experiences with the toolkit. Semi-structured interviews were conducted within the school premises, using a cellular phone as a recording device to capture responses. The interview guides focused on learners' perceptions of toolkit components, their engagement with activities, and the perceived impact on their understanding of integer operations. These interviews provided rich, descriptive data that complemented the quantitative findings.

Treatment of Data

Quantitative data were analyzed using frequency count, percentage, mean, and standard deviation. Frequency and percentage summarized participant profiles; mean determined overall acceptability across content, instructional, and technical quality; and standard deviation assessed response consistency. These tools were appropriate for objectively measuring toolkit effectiveness. Qualitative data were analyzed using Creswell and Creswell (2018) thematic analysis, involving coding, clustering, and theme development. Codes such as "engaging activities" and "confidence improvement" were clustered into themes like learner engagement and perceived effectiveness. Integration of quantitative and qualitative findings strengthened conclusions, with quantitative results establishing effectiveness and qualitative insights explaining learner experiences, ensuring methodological rigor in the mixed-method design.

Ethical Considerations

Ethical standards were observed in accordance with the APA Ethics Code (2017). Ethics clearance was secured from the Schools Division of Aklan. Informed consent was obtained from all participants, who were assured of voluntary participation and the right to withdraw at any time. Learners' anonymity was preserved, and confidentiality was respected in data handling and reporting. Responses were used solely for academic purposes, ensuring integrity, transparency, and compliance with ethical standards.

RESULTS and DISCUSSION

This section presents the results of the acceptability of the developed brain-based mathematics toolkit for integers as evaluated by the experts and learners. The themes and interpretation of data obtained from the participants are also highlighted.

Experts' and Learners' Overall Acceptability of the Brain-Based Mathematics Toolkit for Integers

The table below presented the overall acceptability of the developed brain-based mathematics toolkit for integers as a tool for remediation in terms of content quality, instructional quality, technical quality, and other findings. Five experts and 60 secondary learners examined and evaluated the mathematics toolkit.

Factors	*Students*		*Experts*		*Overall SD*	*Overall Mean*	*Description*
	Mean	*SD*	*Mean*	*SD*			
Content Quality	3.93	0.26	3.92	0.21	0.24	3.93	Highly Acceptable
Instructional Quality	3.91	0.27	3.91	0.22	0.25	3.91	Highly Acceptable
Technical Quality	3.90	0.26	3.91	0.21	0.24	3.90	Highly Acceptable
Other Findings	3.98	0.07	3.96	0.11	0.09	3.97	Highly Acceptable
Overall Rating	3.93	0.11	3.93	0.05	0.07	3.93	Highly Acceptable

Note: Description is based on the following scale: 3.51–4.00 (Highly Acceptable), 2.51–3.50 (Acceptable), 1.51–2.50 (Moderately Acceptable), and 1.00–1.50 (Not Acceptable).

The overall acceptability of the brain-based mathematics toolkit was rated as "highly acceptable" (M = 3.93, SD = 0.07), indicating that it met the required standards in content, instructional design, and technical quality with consistent evaluations across respondents. Both experts and learners perceived the toolkit as effective for remediation in integer operations, and no major revisions were indicated by evaluators. This finding was consistent with the neuroscientific study of Amjada et al. (2023), which demonstrated that brain-based learning strategies significantly enhanced students' mathematical performance, thereby reinforcing the conclusion that instructional materials grounded in brain-based principles can effectively address learners' numeracy difficulties.

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Experts' and Learners' Acceptability of the Brain-Based Mathematics Toolkit for Integers in Terms of Content Quality

Factor A. Content Quality	*Students*		*Experts*		*Overall SD*	*Overall Mean*	*Description*
	Mean	*SD*	*Mean*	*SD*			
1. Content is consistent with topics/skills found in the DepEd Learning Competencies	3.89	0.30	3.90	0.22	0.26	3.90	Highly Acceptable
2. Concepts developed contribute to enrichment, reinforcement, or mastery of the identified learning objectives.	3.91	0.28	3.95	0.18	0.25	3.93	Highly Acceptable
3. Content is accurate.	3.94	0.26	3.95	0.18	0.23	3.95	Highly Acceptable
4. Content is up-to-date.	3.90	0.29	3.90	0.24	0.27	3.91	Highly Acceptable
5. Content is logically developed and organized.	3.93	0.27	3.90	0.22	0.25	3.92	Highly Acceptable
6. Content is free from cultural, gender, racial, or ethnic bias.	3.95	0.26	3.90	0.22	0.24	3.94	Highly Acceptable
7. Content stimulates and promotes critical thinking.	3.98	0.24	3.95	0.18	0.21	3.97	Highly Acceptable
8. Content is relevant to real-life situations.	3.96	0.23	3.95	0.18	0.21	3.96	Highly Acceptable
9. Language (including vocabulary) is appropriate to the target user level.	3.92	0.28	3.90	0.22	0.25	3.93	Highly Acceptable
10. Content promotes positive values that support formative growth.	3.94	0.26	3.90	0.22	0.24	3.94	Highly Acceptable
Overall Rating	3.93	0.26	3.92	0.21	0.23	3.93	Highly Acceptable

Note: Description is based on the following scale: 3.51–4.00 (Highly Acceptable), 2.51–3.50 (Acceptable), 1.51–2.50 (Moderately Acceptable), and 1.00–1.50 (Not Acceptable).

Content quality rated highly acceptable M = 3.93, SD = 0.23), consistent with Olaoluwa (2024) who found that instructional materials grounded in brain-based principles significantly improved students' mathematical performance, especially when content was aligned with cognitive styles and delivered in a structured manner. This alignment between the present result and prior research highlighted the critical role of high-quality content in enhancing learner engagement and achievement in mathematics. This may be due to the toolkit's multimodal features such as

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songs and manipulatives which align with Dual Coding Theory (Stieff et al., 2020). Thus, the findings affirm that integrating multimodal, brain-based strategies into instructional materials not only supports remediation but also promotes long-term retention and deeper conceptual understanding.

Experts' and Learners' Acceptability of the Brain-Based Mathematics Toolkit for Integers in Terms of Instructional Quality

Factor B. Instructional Quality	*Students*		*Experts*		*Overall SD*	*Overall Mean*	*Description*
	Mean	*SD*	*Mean*	*SD*			
1. Purpose of the material is well defined.	3.92	0.26	3.93	0.20	0.24	3.92	Highly Acceptable
2. Material achieves its defined purpose.	3.90	0.29	3.93	0.20	0.25	3.91	Highly Acceptable
3. Learning objectives are clearly stated and measurable.	3.91	0.27	3.88	0.25	0.26	3.90	Highly Acceptable
4. Level of difficulty is appropriate for the intended target user.	3.89	0.30	3.90	0.22	0.26	3.90	Highly Acceptable
5. Graphics / colors / sounds are used for appropriate instructional reasons.	3.89	0.30	3.87	0.26	0.27	3.89	Highly Acceptable
6. Material is enjoyable, stimulating and challenging	3.91	0.27	3.94	0.20	0.25	3.92	Highly Acceptable
7. Material effectively stimulates creativity of target user.	3.93	0.25	3.90	0.22	0.24	3.93	Highly Acceptable
8. Feedback on target user's responses is employed.	3.91	0.27	3.88	0.25	0.26	3.90	Highly Acceptable
9. Target user can control the rate and sequence of presentation and review.	3.93	0.25	3.94	0.20	0.23	3.93	Highly Acceptable
10. Instruction is integrated with target user's previous	3.90	0.29	3.93	0.20	0.25	3.91	Highly Acceptable
Overall Rating	3.91	0.27	3.91	0.22	0.25	3.91	Highly Acceptable

Note: Description is based on the following scale: 3.51–4.00 (Highly Acceptable), 2.51–3.50 (Acceptable), 1.51–2.50 (Moderately Acceptable), and 1.00–1.50 (Not Acceptable).

Instructional quality was rated highly acceptable (M = 3.91, SD = 0.25), consistent with Udofia and Ibok (2025) who found that students taught using brain-based instruction outperformed those in conventional classrooms,

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demonstrating improved retention and equitable learning gains. This alignment between the present result and prior research underscores the effectiveness of brain-based instructional design in enhancing both comprehension and long-term achievement in mathematics. This may be attributed to the toolkit's clear scaffolding and interactive strategies, which resonate with principles of Bruner's Constructivist Learning Theory, emphasizing active learner engagement and the gradual building of conceptual understanding.

Experts' and Learners' Acceptability of the Brain-Based Mathematics Toolkit for Integers in Terms of Technical Quality

Factor C. Technical Quality	*Students*		*Experts*		*Overall SD*	*Overall Mean*	*Description*
	Mean	*SD*	*Mean*	*SD*			
1. Audio enhances understanding of the concept.	3.91	0.26	3.88	0.25	0.25	3.90	Highly Acceptable
2. Speech and narration (correct pacing, intonation, and pronunciation) is clear and can be easily understood.	3.92	0.25	3.93	0.20	0.23	3.93	Highly Acceptable
3. There is complete synchronization of audio with the visuals, if any.	3.90	0.27	3.88	0.25	0.26	3.89	Highly Acceptable
4. Music and sound effects are appropriate and effective for instructional purposes.	3.89	0.28	3.90	0.22	0.26	3.89	Highly Acceptable
5. Screen displays (text) are uncluttered, easy to read, and aesthetically pleasing.	3.92	0.25	3.94	0.20	0.23	3.93	Highly Acceptable
6. Visual presentations (non-text) are clear and easy to interpret.	3.90	0.27	3.90	0.22	0.25	3.90	Highly Acceptable
7. Visuals sustain interest and do not distract user's attention.	3.89	0.28	3.89	0.23	0.25	3.89	Highly Acceptable
8. Visuals provide accurate representation of the concept discussed.	3.91	0.26	3.93	0.20	0.24	3.92	Highly Acceptable
9. The user support materials (if any) are effective.	3.88	0.29	3.90	0.22	0.26	3.89	Highly Acceptable
10. The design allows the target	3.89	0.28	3.91	0.20	0.25	3.90	Highly Acceptable

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user to navigate freely through the material.							
11. The material can easily and independently be used.	3.91	0.26	3.94	0.20	0.24	3.92	Highly Acceptable
12. The material will run using minimum system requirements.	3.88	0.29	3.90	0.22	0.26	3.89	Highly Acceptable
13. The program is free from technical problems.	3.91	0.26	3.93	0.20	0.24	3.92	Highly Acceptable
Overall Rating	3.90	0.26	3.91	0.21	0.24	3.90	Highly Acceptable

Note: Description is based on the following scale: 3.51–4.00 (Highly Acceptable), 2.51–3.50 (Acceptable), 1.51–2.50 (Moderately Acceptable), and 1.00–1.50 (Not Acceptable).

The technical quality of the brain-based mathematics toolkit for integers was rated highly acceptable (M = 3.90, SD = 0.24), consistent with the meta-analysis of Funa et al. (2024), which emphasized that instructional materials grounded in neuroscience principles such as structured sequencing, multimodal engagement, and cognitive load management consistently achieved high standards of technical design and instructional coherence. This alignment between the present result and prior research highlights the toolkit's strong usability, coherent structure, and reliable design features. This may be attributed to its integration of cognitive load theory (Sweller, 1988), which ensures that instructional materials are designed to optimize working memory and facilitate efficient learning, thereby reinforcing both pedagogical effectiveness and technical rigor in classroom implementation.

Experts' and Learners' Acceptability of the Brain-Based Mathematics Toolkit for Integers in Terms of Other Findings

Factor D. Other Findings	*Students*		*Experts*		*Overall SD*	*Overall Mean*	*Description*
	Mean	*SD*	*Mean*	*SD*			
1. Conceptual errors.	3.98	0.09	3.96	0.12	0.11	3.97	Highly Acceptable
2. Factual errors.	3.99	0.00	3.97	0.09	0.06	3.98	Highly Acceptable
3. Grammatical and / or typographical errors.	3.97	0.11	3.95	0.13	0.12	3.96	Highly Acceptable
4. Other errors (i.e., computational errors, obsolete information, errors in the visuals, etc.).	3.98	0.08	3.97	0.10	0.09	3.98	Highly Acceptable
Overall Rating	3.98	0.07	3.96	0.11	0.09	3.97	Highly Acceptable

Note: Description is based on the following scale: 3.51–4.00 (Highly Acceptable), 2.51–3.50 (Acceptable), 1.51–2.50 (Moderately Acceptable), and 1.00–1.50 (Not Acceptable).

The acceptability of the brain-based mathematics toolkit in terms of other findings was rated highly acceptable (M = 3.91, SD = 0.25), consistent with Malonisio & Malonisio (2023), who highlighted their broader applicability to mathematics instruction. This alignment between the present result and prior research underscores that non-print instructional materials grounded in brain-based principles can enhance learning outcomes across disciplines.

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Learners' Experiences in Using the Brain-Based Mathematics Toolkit for Integers

After thorough identification, examination, and interpretation of patterns and themes in the qualitative data following Creswell and Creswell (2018) thematic analysis which involved coding significant statements, clustering related ideas, and refining categories into broader themes. It was found that learners were satisfied with their overall experience in using the brain-based mathematics toolkit for integers. Five secondary learners from Lezo Integrated School during SY 2024–2025 were interviewed to determine their learning experiences with the toolkit. During the interviews, learners were allowed to speak in their mother tongue to better express their thoughts and perspectives.

Interviews were transcribed, open-coded by the researcher, codes grouped into categories and themes. Themes were confirmed by two independent coders. When they were asked about their experiences in the use of the brain-based mathematics toolkit in delivering the lesson, responses highlighted that learners find it (1) cognitively engaging, (2) affectively safe, and (3) effective for remediation.

Cognitively Engaging. The students found the mathematics toolkit cognitively engaging because it fostered active involvement by aligning mathematical tasks with brain-based strategies such as chunking, pattern recognition, and visual–spatial scaffolding. This approach enabled learners to process information more effectively, which reflected their perception of increased conceptual clarity and improved long-term retention of mathematical concepts.

Learner 1 explained that *"First time ko ma'am mag gamit it mathematics toolkit kasi modules and libro paeang ro akong nagagamit. Naila ako sa mga kanta ngato ma'am dahil mas madali para kakon matandaan do rules nga gin ubra nga lyrics sa kanta. Mas madali nakon maalala ro lyrics kaysa mag memorize it meaning."* (This was my first time using a mathematics toolkit instead of modules and textbooks, and I found it easier to understand the lessons. I especially enjoyed the songs, as their lyrics helped me remember the rules for integer operations.)

These findings align with Stieff et al. (2020), who showed that visual chunking and pattern recognition enhance cognitive engagement in mathematics. The toolkit's use of songs and lyrics reflects Dual Coding Theory, where combining verbal and visual codes strengthens memory recall. Collectively, these strategies affirm that multimodal, brain-based interventions can transform abstract mathematical concepts into engaging and memorable learning experiences (Malonisio & Malonisio, 2023).

Affectively safe. Learners identified the mathematics toolkit as fostering a supportive emotional and psychological environment in which they felt safe to experiment, embrace mistakes, and engage in self-paced mathematical discovery. This atmosphere encouraged confidence, reduced anxiety, and promoted a positive disposition toward learning integer operations.

Learner 4 explained that *"Masadya ma'am gamiton ro mathematics toolkit. First time ko maghampang it BINGO sa klase nga about numbers. May mga maze ag puzzles pa ma'am nga very interesting gid nga sabtan. Owa ako napressure nga magdali it answer kasi enough ro time ag in a fun way ro mga activities. Dahil sa toolkit, maeomo ko haintindihan ro mga topic ma'am."* (I enjoyed using the mathematics toolkit, especially playing math BINGO and solving mazes and puzzles. The activities were engaging, not pressured, and helped me understand the topic more easily while having fun.)

Learner 2 added: *"Mas namotivate ako maglearn ma'am kasi gaenjoy ako sa mga experiments. Owa ako nabored ma'am kasi abo nga iba ibang klase nga activities ro among naubra. Masadya ako habang galearn it math."* (I felt more motivated because the varied activities and experiments kept me engaged and prevented boredom.)

The present findings support Gorev et al. (2018), who revealed that integrating puzzles and games into mathematics instruction enhanced learners' thinking, memory, and motivation. Likewise, the toolkit's playful structure reduced performance pressure and encouraged experimentation, fostering resilience and deeper conceptual understanding (Malonisio & Malonisio, 2023).

Effective for Remediation. Learners also agreed that the brain-based mathematics toolkit played a crucial role in supporting struggling students and those with conceptual gaps. It fostered re-engagement with core integer concepts by providing scaffolded activities, tactile representations, and emotionally safe learning routines, thereby promoting both academic improvement and learner confidence.

Learner 5 narrated, *"Nalisdan gid ako dati sa integers ma'am, pero tag nakagamit ako it toolkit hay nag eomo eota para kakon ro mga rules ag mas dasig ko naintindihan. Nakabulig gid sa akong pag review ro pag gamit it toolkit."* (I found it difficult to understand the operations on integers, but when I tried using the toolkit, I found it easier to grasp the rules. It helped me a lot during my review.)

Learner 3 further added, *"Para kakon, mas pinaeomo ma'am ro pagpresent it lesson gamit ro toolkit. Ro dati nga malisod hay mas naintindihan ko eon makaron."* (For me, the lessons in the toolkit are clearly presented, and I can now understand the topics much better)

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These findings attested to what Funa et al. (2024) reported in their study titled Effectiveness of Brain-Based Learning Toward Improving Students' Conceptual Understanding, which provided robust empirical support for the role of brain-based strategies in addressing conceptual gaps among struggling learners. The study highlighted that brain-based learning (BBL) enhanced students' conceptual understanding across disciplines. This result aligned with the observed impact of the mathematics toolkit, which employed scaffolded activities, tactile representations, and emotionally safe routines to re-engage learners with foundational concepts such as integer operations.

Conclusions

The study revealed that the use of the brain-based mathematics toolkit for integers resulted in measurable improvement in the numeracy skills of the learners. Specifically, error rates decreased from 13.71% to 2.54% among junior high learners and from 5.50% to zero among other learners, indicating the toolkit's effectiveness in enhancing performance on integer operations. Learners also expressed satisfaction with their overall experience, describing the toolkit as cognitively engaging, affectively safe, and effective for remediation. These findings are consistent with Elgavi and Hamo (2024), who affirmed that brain-based pedagogical tools can strengthen mathematical abilities through cognitively engaging and emotionally safe strategies.

Recommendations

In view of the study's findings and conclusions, educators and curriculum developers may consider integrating brain-based learning strategies more broadly into mathematics instruction, particularly for foundational topics such as integers. Teachers may design classroom activities that foster both cognitive engagement and affective safety, ensuring that learners feel confident while practicing mathematical operations. To support this, curriculum developers may embed brain-based approaches into instructional materials that can be used for remediation and mastery of basic concepts. Schools may also provide professional development opportunities focused on neuroscience-informed pedagogy so that teachers are equipped to implement these strategies effectively. Furthermore, institutions may encourage the use of reflective learning techniques alongside mathematics toolkits to sustain improvements in learners' mathematical proficiency and promote deeper engagement with numeracy skills.

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