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Math Smart: Numeracy Learning App

Christine Sordilla Gasit[1], Josephine G. Gonzaga[1], April Rose B. Flores, PhD[1]

[1]Master of Technology Education, University of Southern Mindanao, Kidapawan City Campus, Kidapawan City, North Cotabato, Philippines.

Email of Corresponding Author: christine.gasit@deped.gov.ph

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Abstract

This study designed, developed, and evaluated Math Smart: Numeracy Learning App, an offline game-based application intended to strengthen numeracy among multigrade pupils in Grades 3–6. Guided by Constructivist Learning Theory, Experiential Learning Theory, Gamification Theory, and the Technology Acceptance Model, the research adopted a developmental design, Agile software development, and a one-group pre-test–post-test approach. Participants were 40 learners and 10 school personnel at Sixto Fajardo Sr. Elementary School, President Roxas, North Cotabato, during School Year 2025–2026. Researcher-developed numeracy tests and validated acceptability questionnaires assessed performance, graphical user interface, and usability. Built using Android Studio, Java, XML, and SQLite, the application offered grade-specific mathematics exercises, progressive difficulty, randomized items, immediate feedback, rewards, QR-code score verification, and offline progress records. Its content addressed basic operations and word problems based on the Department of Education's Most Essential Learning Competencies. Learners and school personnel rated the interface and usability favorably. The reported Wilcoxon Signed-Rank Test indicated higher post-test performance (reported statistic = 820.00, $p < 0.001$). Findings suggest that Math Smart is an acceptable supplementary resource for numeracy instruction in the participating rural multigrade classroom. Recommended enhancements include more detailed progress monitoring, worked solutions, audio guidance, text-to-speech features, and wider availability. The application contributes to Sustainable Development Goal 4 by supporting foundational learning through offline access in settings with limited connectivity.

Keywords: Educational Technology, Game-Based Learning, Graphical User Interface, Multigrade Learners, Numeracy Skills, Offline Application, Technology Acceptance Model, Usability

1. Introduction

Foundational numeracy enables elementary pupils to calculate, interpret quantitative information, and solve practical problems. Yet difficulties with basic mathematical skills persist, particularly where rural schools combine grade levels and have limited instructional resources (Ökördi & Molnár, 2022). The Department of Education (DepEd, 2024) issued guidelines for implementing the MATATAG Curriculum in basic education. Game-based instruction offers one approach to supporting numeracy development: interactive mathematics activities provide practice, feedback, and active participation that may strengthen learning and motivation (Erşen & Ergül, 2022; Rahayu et al., 2025). Rewards, points, and hints can encourage learners to persist with challenging tasks. In response to these needs, Math Smart: Numeracy Learning App was designed for Grades 3–6 as an offline Android application. Its addition, subtraction, multiplication, division, and simple word-problem activities were developed with reference to the Department of Education's Most Essential Learning Competencies (MELCs; DepEd, 2020). The app combines levels, randomized items, immediate feedback, rewards, and progress monitoring, while SQLite storage supports use without a continuous internet connection.

The literature relevant to Math Smart can be organized around three themes: game-based numeracy learning, acceptance of educational technology, and offline accessibility. Game-Based Learning and Numeracy Development. Research links interactive mathematics games with learner engagement and mathematical achievement (Erşen & Ergül, 2022; Rahayu et al., 2025). Erşen and Ergül (2022) also highlighted the role of curriculum-aligned digital games in supporting interest and achievement. Duraiswamy and Ali Mohammed (2024) reported improved numeracy outcomes with gamified instruction, while Bagacina et al. (2023) discussed playful digital learning for young Filipino pupils. Mobile and game-based approaches have also been examined for arithmetic practice, independent learning, and mathematics performance (De Las Peñas et al., 2020; Jay et al., 2019; Kacmaz & Dubé, 2022; Saleh, 2026). Context matters: Mtebe and Isingo (2024) emphasized locally relevant games; Hidayanthi et al. (2024) explored interdisciplinary digital learning; and Buray and Alferez (2025) investigated game-based numeracy activities for younger pupils. Educational Technology Acceptance and Engagement. The Technology Acceptance Model (TAM) identifies perceived usefulness and perceived ease of use as important factors influencing technology adoption (Davis, 1989). These concepts provide a theoretical basis for evaluating Math Smart's interface, navigation, accessibility, and perceived instructional value. Offline Educational Applications and Accessibility. Offline learning tools are especially pertinent where connectivity and infrastructure are limited. Anggun et al. (2025) recommended offline learning resources for remote primary schools, and Li (2023) discussed barriers associated with internet access in mathematics education. Nabayra (2024) examined an Android mathematics tool in geographically challenged communities, while Mtebe and Isingo (2024) underscored the importance of matching games to local resources and learners' needs. Together, these studies support the development of interactive mathematics tools that remain usable without reliable connectivity.
At the local level, Math Smart responds to numeracy-learning needs at Sixto Fajardo Sr. Elementary School in Barangay La Esperanza, President Roxas, North Cotabato. The school's rural multigrade setting and limited connectivity provide a practical rationale for an offline, grade-appropriate learning tool. At the national level, Insorio (2020) explored an offline numeracy application for older students, Garcia and Pasia (2024) examined game-based mathematics learning among Grade 2 pupils, and Buray and Alferez (2025) investigated digital game-based numeracy instruction among Grade 1 learners. These studies indicate the relevance of technology-assisted mathematics activities, but their learner groups differ from the Grades 3–6 multigrade population examined here. International research also offers useful comparisons: Duraiswamy and Ali Mohammed (2024) studied gamified numeracy instruction in India; Mtebe and Isingo (2024) investigated locally developed games in Tanzania; Hidayanthi et al. (2024) examined digital approaches in Indonesia; and Debrenti (2024) explored game-based primary mathematics learning in Romania. Their findings reinforce the importance of adapting digital instruction to its educational context.
Four perspectives guide the study: Constructivist Learning Theory, Experiential Learning Theory, Gamification Theory, and the Technology Acceptance Model. Constructivist Learning Theory. Piaget (1972) described learning as the active construction of knowledge through interaction with the environment. Math Smart applies this principle through progressively challenging mathematics exercises that require learners to solve problems. Experiential Learning Theory. Kolb (1984) emphasized learning through experience, reflection, conceptualization, and application; interactive tasks, assessment, and progress feedback offer related opportunities for practice and reflection (Kolb & Kolb, 2017, 2022). Gamification Theory. Deterding et al. (2011) described the use of game-design elements in nongame contexts. Math Smart incorporates rewards, levels, and challenges to encourage participation. Technology Acceptance Model. Davis (1989) identified perceived usefulness and ease of use as central to technology acceptance; these dimensions inform the application's GUI and usability evaluation.
An Input-Process-Output (IPO) framework further organizes the project. Inputs include ideas, references, equipment, development materials, internet resources used during development, and software. Processes encompass planning, preparation, development, testing, revision, and evaluation. The output is an offline numeracy learning application for multigrade elementary pupils.
Despite promising evidence for digital mathematics games, important questions remain about their use in rural Philippine multigrade classrooms. Some studies address older learners or contexts with different technological resources. Erşen and Ergül (2022) noted the need for further work with younger pupils, whereas Insorio (2020) studied older students without specifically assessing application acceptance using TAM. Nabayra (2024) examined mobile mathematics learning in geographically challenged settings; Anggun et al. (2025) and Li (2023) discussed infrastructure and connectivity constraints. The reviewed literature provides limited evidence about applications combining offline operation, grade-specific numeracy activities, user acceptability, and measured learning performance for rural multigrade pupils. Consistent with the Technology Acceptance Model (Davis, 1989), both educational outcomes and practical acceptability warrant evaluation.
The study relates primarily to Sustainable Development Goal 4 (Quality Education) and Sustainable Development Goal 9 (Industry, Innovation and Infrastructure). SDG 4 – Quality Education. Math Smart provides curriculum-referenced mathematics practice, differentiated grade-level activities, immediate feedback, and progressive challenges intended to strengthen foundational numeracy. Because the app operates offline, pupils may engage with digital learning activities despite connectivity constraints. SDG 9 – Industry, Innovation and Infrastructure. Developing an Android application with local storage, progress monitoring, and game-based features illustrates a technology solution adapted to limited infrastructure. These connections concern educational access and practical innovation rather than evidence of broad implementation beyond the study setting.

Math Smart also has potential educational, technological, social, and institutional relevance. Educationally, its supplementary mathematics exercises may encourage repeated practice, engagement, and differentiated instruction. Alignment with the Department of Education's Most Essential Learning Competencies connects the activities to specified learning objectives. Recorded performance may help teachers identify skills that require additional support. These possible contributions are especially relevant in multigrade classrooms, where learners need activities suited to different levels.

From a technological perspective, offline Android functionality and local SQLite storage reduce dependence on uninterrupted internet service. Learner activities and assessment records remain available on the device. Socially, this design may broaden access to digital numeracy practice for pupils in resource-constrained communities. Institutionally, findings on interface acceptability, usability, and performance can inform decisions by teachers, administrators, and curriculum developers about comparable learning tools. Overall, the study examines an accessible approach to technology-supported mathematics instruction within one rural multigrade school.

2. Material and methods

2.1 Research Design

The study adopted a developmental research design to create, implement, and evaluate an offline game-based numeracy application. Design and development research systematically examines instructional products and their design, testing, and evaluation (Richey & Klein, 2007). A one-group pre-test–post-test approach was also used to describe changes in numeracy scores after the intervention. Application development followed an Agile process involving planning, design, development, testing, feedback, and revision. Classroom observations, consultations with teachers, and review of the Department of Education's Most Essential Learning Competencies (MELCs; DepEd, 2020) informed the content. Android Studio, Java, XML, and SQLite were used to develop registration, grade-level activities, scoring, feedback, rewards, and teacher monitoring features. Testing addressed functionality, navigation, compatibility, content accuracy, and usability; revisions were informed by learner and evaluator feedback. Resources included a computer, Android devices, multimedia tools, and local storage equipment. The estimated development period was 15 days, with a project budget of ₱14,000 covering materials, programming, design, and miscellaneous costs.

2.2 Locale of the Study

The research took place during School Year 2025–2026 at Sixto Fajardo Sr. Elementary School, Barangay La Esperanza, President Roxas, North Cotabato. This rural school serves multigrade pupils and experiences limitations in technology resources and internet connectivity. It was selected as an appropriate setting in which to examine the accessibility, usability, and learning outcomes associated with an offline numeracy application.

2.3 Respondents of the Study

The study involved 50 participants: 40 multigrade learners and 10 evaluators. The learner group comprised 10 pupils each from Grades 3, 4, 5, and 6. They completed pre-tests, app-based numeracy activities, and post-tests. The evaluator group consisted of multigrade teachers, the school head, and other school personnel involved in instruction. They assessed the application's GUI, usability, learner engagement, curriculum alignment, and suitability for classroom use.

2.4 Sample and Sampling Procedure

Complete enumeration was reported as the sampling approach for the identified multigrade classes and participating school personnel. The study included 40 pupils across Grades 3–6 and 10 evaluators during School Year 2025–2026. Learners were included because they required support in fundamental operations, while teachers and staff were selected for their involvement with the target classes and their capacity to assess the application's usability and instructional relevance.

2.5 Research Instrument

Data were collected through researcher-developed numeracy pre-tests and post-tests and an application acceptability questionnaire. Assessment content addressed addition, subtraction, multiplication, division, and simple word problems based on the Department of Education's Most Essential Learning Competencies (MELCs; DepEd, 2020). Questions were organized at Easy, Medium, and Hard levels. The pre-test measured baseline performance, and the post-test measured performance after the intervention. The questionnaire evaluated graphical user interface and usability, including design, layout, icons, navigation, responsiveness, instructions, and offline access. Responses used a five-point scale: Highly Acceptable (4.50–5.00), Acceptable (3.50–4.49), Moderately Acceptable (2.50–3.49), Slightly Acceptable (1.50–2.49), and Not Acceptable (1.00–1.49). Graduate School faculty with expertise in elementary mathematics and instructional technology reviewed the instruments. Their feedback informed revisions, and pilot testing was conducted to refine items, response options, and scoring procedures. The questionnaire was described as Highly Acceptable following expert review.

2.6 Data Gathering Procedure

Data gathering proceeded through pre-development, development, implementation, and post-development stages. Before the study, the researcher sought permission from the school principal and coordinated with teachers. Faculty evaluators were invited to assess the application. Parents or guardians provided informed consent, and participating pupils provided assent; participants were informed of the study's purpose, voluntary nature, confidentiality protections, and right to withdraw. A pre-test established baseline numeracy performance, while observations and teacher consultations guided activity design. During implementation, teachers introduced Math Smart in designated classroom or supplementary mathematics sessions and facilitated access through grade-level group chats and an application link. Pupils completed randomized exercises at different difficulty levels and received scores, feedback, and rewards. The application stored records locally in SQLite. Teachers and faculty evaluators observed its operation and assessed functionality, navigation, usability, and instructional suitability. After implementation, pupils completed a post-test and participants answered acceptability questionnaires. Results were then organized for statistical analysis.

2.7 Data Analysis Techniques

Descriptive and inferential procedures were used to analyze the data. Frequencies and percentages described participants and aspects of the application (Creswell & Creswell, 2018). Means and standard deviations summarized GUI and usability ratings, which were interpreted using the stated five-point acceptability scale. To examine changes in numeracy performance, the reported analysis used the Wilcoxon Signed-Rank Test to compare paired pre-test and post-test scores at the 0.05 significance level. These analyses informed the assessment of Math Smart's acceptability and its association with numeracy performance following the intervention.

3. Results and Discussion

3.1 Design and Development of Math Smart: Numeracy Learning App

3.1.1 Application Design and Functional Features

The project produced an offline Android numeracy application with content referenced to the Department of Education's Most Essential Learning Competencies for Grades 3–6. Activities address addition, subtraction, multiplication, division, and basic word problems. Features include grade-specific exercises, Easy/Medium/Hard levels, randomized questions, feedback, timers, rewards, learner registration, pre-tests, post-tests, QR-code score verification, and a teacher monitoring dashboard. The interface uses readable text, clear directions, accessible buttons, and locally stored records. The design accommodates different grade levels by allowing pupils to work on activities matched to their learning needs. Randomized items, increasing difficulty, and prompt feedback provide opportunities for repeated practice. Its rewards and challenges reflect the use of game-design elements in educational settings described by Deterding et al. (2011).

3.1.2 Application Development and System Functionality

Math Smart was implemented with Android Studio, Java, XML, and SQLite, with Canva and other graphic-editing tools used for interface assets. QR-code libraries supported score verification. Pupils could complete activities, receive results, and generate codes for teacher checking; teachers could manage questions, review scores, monitor progress, and organize grade-level content. Local storage enabled the app to operate without constant internet access. Development followed an Input-Process-Output sequence of preparation, design, testing, revision, and evaluation, consistent with the instructional development processes discussed by Richey and Klein (2007).

3.1.3 System Interaction and Data Management

The Math Smart application was designed with two primary user roles: teachers and learners. Teachers were responsible for approving learner accounts, managing numeracy questions, verifying QR-coded assessment results, and monitoring learner progress. Learners could access their accounts, complete baseline assessments, participate in grade-appropriate numeracy activities, receive immediate feedback, and undertake post-test assessments. The application automatically calculated scores and stored assessment records in its local SQLite database. This role-based structure facilitated systematic progress monitoring, organized assessment records, and efficient management of classroom learning activities.

3.2 Acceptability of Math Smart: Numeracy Learning App

3.2.1 Learners' Evaluation of Graphical User Interface

Forty learners rated the graphical user interface (GUI) Acceptable, with an overall mean of 4.41. Visual appeal and engagement received the highest mean (4.60); ease of login and icon clarity each received 4.55. Button accessibility and appropriateness of mathematical information each scored 4.50. Text and picture size had the lowest mean (4.15), classified as Acceptable. Twenty-eight learners (70.0%) assigned the highest rating to visual appeal, compared with 16 (40.0%) for text and picture size. Overall, the findings suggest favorable perceptions of the interface, although text and image sizing may need improvement. These results are consistent with Seifi and Moshayeri (2024), who discussed clarity and consistency in user experience, and Talarico (2025), who considered the role of organized multimedia in learning.

3.2.2 Teachers' and Staff's Evaluation of Graphical User Interface

Ten teachers and school personnel rated the GUI Acceptable, with an overall mean of 4.45. Icon clarity and visual appeal each received 4.60. Ease of login, clarity of symbols, button accessibility, and appropriateness of mathematical information each received 4.50, whereas text and picture size received 4.20. Seven evaluators (70.0%) gave the highest rating to icons and visual appeal; four (40.0%) did so for text and picture size. These results indicate positive perceptions of the interface, alongside an opportunity to improve readability. Li et al. (2022) discussed consistency and interaction in interface design, while Maier (2025) highlighted the educational importance of clear visual and textual presentation.

3.2.3 Learners' Evaluation of Application Usability

Learners' overall usability rating was 4.36, interpreted as Acceptable. Ease and convenience received the highest mean of 4.60. Ease of opening the app, instructions, readability, and sequence of learning levels each scored 4.50. Relevance and accuracy of answer choices had the lowest mean (4.15). Twenty-eight learners (70.0%) gave the highest rating to convenience, while 16 (40.0%) did so for answer-choice relevance and accuracy. These results suggest that pupils generally found the application manageable, but answer choices warrant further refinement. Pratiwi et al. (2023) examined usability in practical settings, and Tamilmani et al. (2021) identified effort expectancy and facilitating conditions as factors in technology adoption.

3.2.4 Teachers' and Staff's Evaluation of Application Usability

Teachers and staff rated application usability Acceptable, with an overall mean of 4.43. Overall ease and convenience scored 4.60. Opening the application, clarity of directions, readability, and the sequence of activities each received 4.50. Relevance and accuracy of answer choices had the lowest mean (4.20). Seven evaluators (70.0%) assigned the highest rating to convenience, while four (40.0%) did so to answer-choice relevance and accuracy. These evaluations suggest that the app can support classroom activities with relatively few operational difficulties. Ferreira et al. (2022) examined usability in relation to efficiency, effectiveness, and satisfaction, while Davis (1989) identified perceived ease of use as relevant to technology acceptance.

3.3 Effectiveness of Math Smart: Numeracy Learning App on Learners' Performance

3.3.1 Pre-Test and Post-Test Performance

Among the 40 participating pupils, numeracy scores were reported to improve from pre-test to post-test after using Math Smart. The Wilcoxon Signed-Rank Test was reported as statistically significant, with a test statistic of 820.00 and $p < 0.001$. The direction of the reported change favored the post-test. This pattern suggests that the intervention was associated with improved performance in the participating group, although a one-group design cannot by itself rule out other explanations for the change. The learning activities, increasing challenges, and immediate feedback may have contributed to engagement and practice. Kucher (2021) discussed active learning in game-based environments, and Chen and Tu (2021) examined motivation and cognitive engagement in digital game-based learning.

3.3.2 Statistical Significance of Learning Improvement

The reported Wilcoxon Signed-Rank Test found a difference between paired pre-test and post-test scores ($p < 0.001$). Because the reported p-value was below 0.05, the null hypothesis of no difference was rejected. Post-test performance was higher for the participating learners. Duterte (2024) discussed engagement in technology-enhanced learning, providing context rather than independent evidence for this study's score changes. Mikrouli et al. (2024) considered learning outcomes associated with serious games, Morata (2024) reported numeracy improvements following digital game-based activities, and Munda et al. (2024) examined structured numeracy interventions. These studies provide related educational context for the observed results.

3.4 Relevance of Offline Game-Based Learning in Rural Multigrade Classrooms

3.4.1 Offline Accessibility and Educational Application

Math Smart functioned offline by storing learner profiles, scores, and progress records on the device. Pupils could access grade-specific exercises without continuous internet connectivity, while teachers could review progress and verify results through QR codes and monitoring tools. This design addressed the need for an accessible learning resource in the participating rural classroom. Anggun et al. (2025) discussed infrastructure limitations and recommended offline resources for remote schools; Li (2023) identified connectivity barriers to mathematics learning. Nabayra (2024) studied Android-based mathematics instruction in geographically challenged settings. These findings offer relevant context, but results from different learner populations should not be assumed to apply directly to rural multigrade elementary pupils.

3.4.2 Instructional Suitability for Multigrade Learners

Grade-specific exercises, adjustable difficulty, randomized questions, rewards, and teacher-managed assessments enabled pupils in Grades 3–6 to engage with assigned numeracy activities. Acceptable GUI and usability ratings, together with higher post-test scores, indicate that Math Smart was suitable as a supplementary tool in the participating classroom. Anggun et al. (2025) and Li (2023) discussed the need for learning resources adapted to

infrastructure constraints. Buray and Alferez (2025) examined digital game-based numeracy learning, while Mtebe and Isingo (2024) emphasized local relevance in educational game design. Taken together, these perspectives support further evaluation of offline game-based learning in comparable multigrade settings.

4. Conclusion & Recommendations

The study developed and evaluated Math Smart: Numeracy Learning App as an offline supplementary resource for Grades 3–6 multigrade learners. The Android application uses Java, XML, and SQLite and includes grade-level mathematics activities, increasing difficulty, randomized items, feedback, rewards, and progress records based on the Department of Education's Most Essential Learning Competencies. Learners and school personnel rated its graphical user interface and usability Acceptable. The reported Wilcoxon Signed-Rank Test showed higher post-test scores and a statistically significant pre-test–post-test difference. These findings suggest that the application is a promising instructional supplement for the participating rural classroom, while broader effectiveness requires evaluation in additional settings and with stronger comparative designs.

Future development should prioritize more detailed progress tracking and step-by-step explanations for incorrect responses. Audio instructions and text-to-speech features may improve accessibility for pupils with different learning needs. Additional resources may support distribution through the Google Play Store and wider classroom testing. Subsequent studies should examine the application with larger or comparison groups and document implementation conditions before drawing broader conclusions.

5. Compliance with ethical standards

The manuscript reports that permission was obtained from the Schools Division Office of Panabo City and participating school principals. Because the stated study site is Sixto Fajardo Sr. Elementary School in President Roxas, North Cotabato, the approving office must be checked against the signed research authorization before publication. The study reports informed consent, including parental or guardian consent for pupils, voluntary participation, withdrawal without penalty, and protection of privacy through coded responses, secure storage, and aggregate reporting. These procedures are described in relation to the Data Privacy Act of 2012 (Republic Act No. 10173) and applicable Philippine ethical research guidelines.

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