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Technology-Enhanced Mathematics Learning: Assessing the Effectiveness of Mobile Applications among Grade 11 Students

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ABSTRACT

This descriptive-correlational study examined the commonly used mobile learning applications, the extent of application use, perceived effectiveness in developing mathematical literacy, and their relationships with General Mathematics academic performance among Grade 11 students at Dr. Cecilio Putong National High School–Senior High School, Tagbilaran City, during School Year 2025–2026. Using stratified random sampling, 220 learners were selected from a population of 490 across 17 sections. A researcher-developed, expert-validated questionnaire (pilot-test Cronbach's α = .83) assessed three dimensions of use and three dimensions of perceived effectiveness; students' grades were obtained from authorized school records. Data were summarized using frequencies, percentages, weighted means, and Pearson correlation analysis. Desmos (51.82%), Khan Academy (27.27%), and Gauthmath (26.82%) were the most commonly reported applications. The overall extent of use was high (M = 2.70), and perceived effectiveness was rated effective (M = 2.87). Learners' mean General Mathematics grade was 86.74 (very satisfactory). The reported overall relationship between extent of use and academic performance was nonsignificant (p = .075), whereas perceived application effectiveness was positively associated with performance (r = .275, reported p = .000). The findings emphasize purposeful, supported use of mobile applications rather than use frequency alone and informed a proposed Math Mentor Xpress peer-tutoring action plan. As the design was correlational, no causal effect was established.

Keywords: *mobile learning applications, General Mathematics, mathematical literacy, perceived effectiveness, academic performance, Grade 11 students*

INTRODUCTION

Mobile learning applications have become increasingly available to secondary learners for reviewing mathematical concepts, manipulating graphs, solving problems, and checking answers. Their instructional value, however, depends on more than access or frequency of use. Mobile tools may provide timely feedback and flexible opportunities to revisit challenging tasks, but productive learning requires an appropriate match among tool features, curriculum objectives, and students' needs. International evidence suggests that technology-supported learning produces benefits when it is deliberately integrated into teaching and assessment (Cheung & Slavin, 2013; Sung et al., 2016; Tingir et al., 2017).

General Mathematics requires learners to reason with representations, choose appropriate procedures, and apply mathematical knowledge to everyday situations. The Philippine results of the Programme for International Student Assessment have made mathematical proficiency an important educational concern (OECD, 2023). In the local setting of Tagbilaran City, learners encounter mobile learning tools both in classroom-related work and

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independent study. Nevertheless, application use itself does not demonstrate that learners understand concepts, identify errors, or attain higher grades. This distinction makes it necessary to examine the extent of use and perceived usefulness separately.

The existing literature discusses mobile-assisted learning, instructional technology, and student achievement, but the relationship between particular patterns of application use, perceived contribution to mathematical literacy, and school-recorded General Mathematics performance requires context-specific evidence. In particular, the experiences of Grade 11 students in a local public senior high school may differ from findings generated in other age groups or learning environments. Mobile technology acceptance and self-regulation research also suggests that adoption, persistence, and educational benefit need not be identical outcomes (Açıkgül & Şad, 2021; Baars et al., 2022; Davis, 1989).

Accordingly, this study determined the mobile applications commonly used by Grade 11 students of Dr. Cecilio Putong National High School–Senior High School; assessed the extent of their use in terms of learning tasks, classroom integration, and independence; evaluated perceived effectiveness in terms of task accuracy and efficiency, interactive concept exploration, and solution verification; described academic performance from General Mathematics grades; and tested the relationships between academic performance and both app-use and app-effectiveness measures. Findings were used to formulate a school-based action plan rather than to claim experimental improvement.

Literature Review

Mobile learning and mathematics achievement

Mobile technologies can extend mathematics learning beyond scheduled instruction by supporting independent practice, resource retrieval, and repeatable exploration. Sung et al. (2016) synthesized educational applications of mobile devices and reported a moderate overall benefit across experimental and quasi-experimental research; Tingir et al. (2017) likewise examined mobile-device integration in K–12 learning. However, such cross-study results do not establish that every type of use is equally beneficial. The design and organization of instructional tasks remain relevant to interpreting technology-supported academic outcomes.

In mathematics specifically, Cheung and Slavin (2013) found generally positive but modest effects of educational technology in K–12 classrooms. The potential value of applications is therefore not reducible to device availability or application popularity. For the present investigation, learning-task completion, classroom integration, and use independence were treated as separate dimensions of frequency and practice, while academic performance was measured independently through school grades.

Mobile learning environments can help teachers diversify the delivery of mathematical ideas using guided examples and adaptive activities. Annuš and Kmeť (2024) described opportunities for personalized K–12 mathematics learning, while Aljas et al. (2025) discussed the use of digital tools in senior high school General Mathematics. These studies underscore the importance of considering how instructional design may translate technological affordances into actual learning experiences, while leaving open the question of how students' own evaluations relate to their mathematics grades.

Technology acceptance and self-regulated application use

The Technology Acceptance Model distinguishes perceived usefulness and ease of use as influences on technology acceptance (Davis, 1989). The extended Unified Theory of Acceptance and Use of Technology similarly considers facilitating conditions and habit (Venkatesh et al., 2012). These perspectives help explain why students may repeatedly choose accessible platforms, but they do not establish that frequent use necessarily predicts academic achievement. Açıkgül and Şad (2021) situated mobile-technology acceptance within high school mathematics learning, demonstrating the relevance of learner perceptions in this subject.

Independent use may also involve locating tools, managing study time, navigating tutorials, and selecting applications suited to a mathematical task. Baars et al. (2022) explored how a mobile application can support

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students' self-regulated learning processes. Thus, independent use in the present study was assessed alongside direct task use and classroom integration, rather than being assumed to be a by-product of having a mobile phone.

Digital participation can be increased by feedback, goals, and opportunities to repeat tasks. Hamari et al. (2014) reviewed gamification research, and Rüth et al. (2021) examined learning with mobile quiz-app feedback. Nevertheless, applications that provide automatic answers without requiring mathematical explanation may not produce the same experiences as tools used for inquiry and solution checking. Such differences reinforce the need to analyze reported usefulness separately from simple usage frequency.

Mathematical literacy, multimedia learning, and feedback

Mathematical literacy involves interpreting and applying concepts rather than relying solely on routine computation. Dynamic graphs, multiple representations, and responsive examples may enable learners to investigate mathematical patterns. Mayer (2009) explained how coordinated visual and verbal representations can facilitate learning, whereas Sweller (1988) cautioned that poorly structured tasks may overload working memory. In this study, interactive concept exploration was accordingly one of three perceived-effectiveness dimensions.

Timely feedback may help learners recognize procedural errors and refine explanations. Hattie and Timperley (2007) examined feedback as a mechanism for learning, and Rüth et al. (2021) described the importance of feedback type in mobile quizzes. The measures of accuracy and efficiency, interactive concept exploration, and solution verification were designed to distinguish these educational functions. Their scores reflected learners' perceptions, not a separate standardized assessment of mathematical literacy.

Social learning perspectives further stress guided practice and supportive interaction. Bandura (1977) highlighted learning through observation, while Vygotsky (1978) emphasized learning with assistance. These perspectives suggest that peer discussion and teacher-supported use of applications may provide opportunities to explain solutions rather than simply display final answers. Schunk and DiBenedetto (2020) likewise discussed the relationship of social cognitive processes and motivation, which provides a rationale for integrating feedback and guided practice in the proposed tutorial plan.

Instructional policy and conceptual synthesis

In the Philippine basic education context, the Department of Education's guidelines on daily lesson preparation support purposeful instructional planning (Department of Education, 2016), while the Basic Education Learning Continuity Plan recognized the need for flexible modalities and accessible resources (Department of Education, 2020). These policy considerations provide context for responsible integration of mobile mathematics resources, but do not substitute for evidence of improved grades. The study also relates to the United Nations (2015) commitment to inclusive quality education and numeracy.

Taken together, the literature supports investigating application access, purpose, and perceived learning contribution as conceptually related but distinct elements. The original study combined technology acceptance, learning theory, and Philippine education policies with three observed domains: perceived use, perceived effectiveness, and General Mathematics performance. The framework illustrated below retains the labels and relationships of the thesis's Figure 1 and situates the present descriptive-correlational analysis within this instructional setting.

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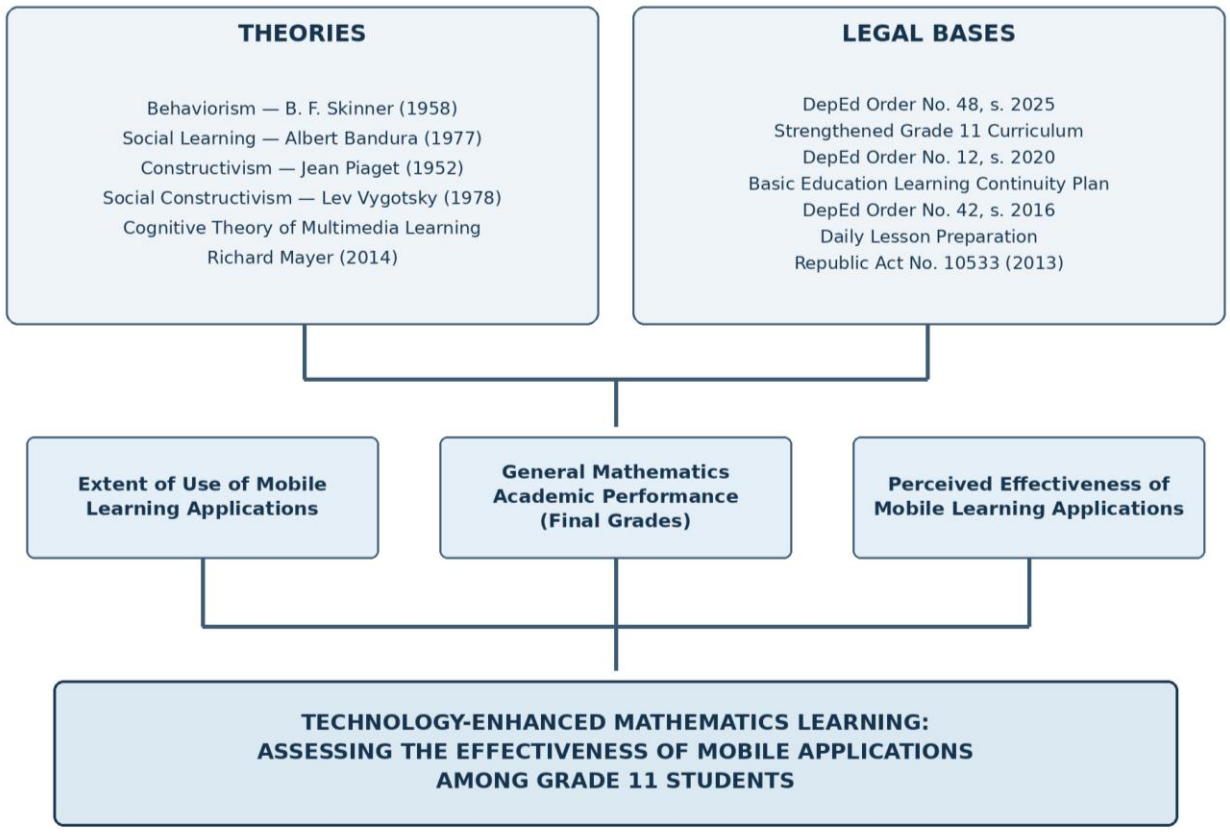


Figure 1. Theoretical–conceptual framework of the study

METHODS

Research Design

The study used a quantitative, cross-sectional descriptive-correlational design. No intervention was introduced or manipulated. The descriptive component characterized the applications commonly used, the extent and perceived effectiveness of application use, and mathematics grades. Pearson correlation analysis examined whether app-use and app-effectiveness scores were statistically related to Grade 11 General Mathematics academic performance (Creswell & Guetterman, 2019).

Research Locale

Data were gathered at Dr. Cecilio Putong National High School–Senior High School (annex campus) in Purok 2, Cabawan, Tagbilaran City, Bohol, Philippines, during School Year 2025–2026. The site was selected because the school offered Grade 11 General Mathematics and provided an appropriate setting for examining how learners used mobile applications in school-related and independent mathematical work.

Participants and Sampling Technique

The study population comprised 490 Grade 11 students from 17 sections. Using Slovin's formula with a reported 5% margin of error, the researcher determined a sample of 220 respondents. Stratified random sampling by section was implemented to provide representation across the school's Grade 11 groups. The quantitative analysis used these 220 completed cases.

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Research Instrument

A researcher-developed questionnaire contained four parts: commonly used mobile learning applications; extent of use for learning tasks, classroom activities, and independent study; perceived effectiveness for accuracy and efficiency, interactive concept exploration, and solution verification and error correction; and General Mathematics academic performance. Expert validators reviewed the instrument, and a pilot administration involving 30 students outside the main sample produced a reported overall Cronbach's alpha of .83. App-use and perceived-effectiveness items used four-point response scales, interpreted using the thesis's prespecified cutoffs.

Data Gathering Procedure

The researcher obtained permissions from the Tagbilaran City Schools Division and school authorities before conducting the study. Eligible respondents received an explanation of the research, the voluntary nature of participation, and instructions for completing the questionnaire. The surveys were personally distributed and subsequently checked, compiled, and encoded. With school authorization, relevant General Mathematics grades were obtained from academic records and matched through coded records for analysis.

Data Analysis

Frequencies and percentages were used to describe the commonly used applications and the distribution of grades. Weighted means and standard deviations summarized the extent-of-use and perceived-effectiveness responses. The three extent-of-use domains were scored as types of learning tasks, classroom integration, and learning independence; the effectiveness domains were accuracy and efficiency, interactive exploration, and solution verification. Pearson's product–moment correlation was used for associations with academic performance at $\alpha = .05$. Statistical processing was performed using IBM SPSS, as described in the thesis. The self-report effectiveness measure is interpreted as perceived benefit rather than an experimentally observed effect.

Ethical Consideration

The researcher reported obtaining institutional clearance, parental or guardian informed consent, and student assent before data collection. Participation was voluntary, and coded responses were handled confidentially. School-recorded grades were accessed only with authorization. The thesis described safeguards guided by the Data Privacy Act of 2012 (Republic Act No. 10173) and the Department of Education's child-protection expectations. The researcher also maintained separation between research participation and grading responsibilities.

RESULTS AND DISCUSSION

Commonly used mobile learning applications

The respondents reported using several tools for mathematical practice, explanations, graphing, answer checking, and instructional resources. Desmos was the leading application, reported by 114 learners (51.82%), followed by Khan Academy (60; 27.27%), Gauthmath (59; 26.82%), and Photomath (42; 19.09%). Respondents were able to identify more than one application, so the percentages are not mutually exclusive and should not be added as a single distribution. These preferences suggest interest in applications that combine mathematics-specific functions and accessible support.

Table 1. *Most commonly reported mobile learning applications (N = 220)*

Application	n	%
Desmos	114	51.82
Khan Academy	60	27.27
Gauthmath	59	26.82
Photomath	42	19.09

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CalcES	31	14.09
YouTube	21	9.55
Quizizz	19	8.64
GeoGebra	18	8.18

From a technology-acceptance perspective, a frequently reported application may be familiar or convenient as well as educationally useful (Davis, 1989; Venkatesh et al., 2012). The popularity counts, however, do not demonstrate comparative application effectiveness. Instead, they identify practical platforms that can be considered for structured instructional activities within the school.

Extent of mobile learning application use

The overall extent of mobile learning application use was rated high (grand mean = 2.70, SD = .92). Among the dimensions, task-related use was highest (M = 2.82), followed by independent use (M = 2.75); integration with classroom activities was lowest, although still within the high category (M = 2.54). Looking up formulas and definitions (M = 3.02), checking classroom announcements and tasks (M = 3.03), and searching for or downloading study applications (M = 2.92) were among the most strongly endorsed uses.

Table 2. *Summary of perceived extent of mobile learning application use*

Dimension	Mean	SD	Interpretation
Learning tasks accomplished	2.82	0.88	High extent
Integration with classroom activities	2.54	0.98	High extent
Level of independence	2.75	0.91	High extent
Overall	2.70	0.92	High extent

The more limited use of live gamified quizzes (M = 1.86), collaborative classroom tasks (M = 2.39), and mathematics games (M = 2.28) indicates that learners did not use all application functions to the same extent. While students regularly sought information or solved individual tasks, these reported practices were less often translated into interactive classroom participation. This distinction supports the value of planned peer-supported activities and teacher-designed exploration tasks, consistent with scholarship on technology integration and learning regulation (Baars et al., 2022; Hamari et al., 2014).

Perceived effectiveness in developing mathematical literacy

Respondents considered mobile learning applications effective for the three targeted aspects of mathematical literacy (overall mean = 2.87). Solution verification and error correction received the highest assessment (M = 2.99), followed by accuracy and task efficiency (approximately M = 2.92–2.93) and interactive concept exploration (M = 2.71). Among individual functions, checking handwritten answers (M = 3.14), identifying errors (M = 3.10), and using step-by-step correction guidance (M = 3.08) were especially valued. Connecting mathematics to real-world applications also received a favorable mean of 2.93.

Table 3. Reported perceived effectiveness of mobile learning applications

Dimension	Mean	SD	Interpretation
Accuracy and task efficiency	2.92*	1.06	Effective
Interactive concept exploration	2.71	0.88	Effective
Solution verification and error correction	2.99	0.94	Effective
Overall	2.87	0.96	Effective

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The results are consistent with the instructional importance of timely feedback and representations that allow learners to revisit reasoning (Hattie & Timperley, 2007; Mayer, 2009). Still, the ratings describe what students believed the applications helped them do; they do not establish measured gains on an independent mathematical literacy test. Comparatively weaker ratings for gamified exploration and immediate understanding checks suggest room for guided inquiry and discussion rather than solely automated answer verification.

General Mathematics academic performance

Grade 11 respondents recorded a mean General Mathematics grade of 86.74 (SD = 5.36), interpreted in the thesis as very satisfactory. Most learners obtained grades in the satisfactory-to-outstanding ranges, and none were recorded below 75. These school-recorded grades provided an independent academic outcome for the correlational analyses; they were not pre-test/post-test measures of an application intervention.

Table 4. *Distribution of General Mathematics academic performance (N = 220)*

Grade range	Description	n	%
90–100	Outstanding	75	34.09
85–89	Very satisfactory	70	31.82
80–84	Satisfactory	53	24.09
75–79	Fairly satisfactory	22	10.00
Below 75	Did not meet expectations	0	0.00
Total		220	100.00

Note. Overall mean grade = 86.74; SD = 5.36

That generally favorable performance must not be interpreted as an effect of mobile learning applications because the research design involved no controlled comparison and no manipulation. The role of the recorded grades was to examine whether variation in learners' self-reported use and perceived effectiveness coincided with variation in academic achievement.

Relationships of application use and effectiveness with academic performance

The study reported no statistically significant overall relationship between academic performance and the extent of application use (reported r = .271, p = .075), although the level-of-independence subscale was positively related to grades (r = .196, p = .003). Use for particular learning tasks (r = .067, p = .324) and classroom integration (reported r = −.300, p = .662) were described as nonsignificant. The latter two source-reported coefficient–p-value pairings contain internal inconsistencies, and their exact entries require reconciliation with the original SPSS tables before journal submission.

In contrast, the overall perceived effectiveness of mobile learning applications had a reported positive, statistically significant relationship with General Mathematics academic performance (r = .275, p reported as .000). The accuracy-and-efficiency (r = .191, p = .004), interactive-exploration (r = .226, p = .001), and solution-verification (r = .297, p reported as .000) dimensions were likewise positive and significant. This pattern suggests that students' perceptions of meaningful assistance were more consistently associated with grades than simple usage extent, but it does not demonstrate that app effectiveness caused higher performance.

Table 5. *Thesis-reported Pearson correlations with General Mathematics grades*

Predictor	r	Reported p	Decision
Overall extent of use	.271	.075	Not significant
Learning tasks	.067	.324	Not significant
Classroom integration	−.300	.662	Not significant
Independent use	.196	.003	Significant
Overall perceived effectiveness	.275	.000	Significant
Accuracy and efficiency	.191	.004	Significant

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Interactive exploration	.226	.001	Significant
Solution verification	.297	.000	Significant

These results encourage a more nuanced view of classroom technology. Frequent access may be used for reminders, downloading content, or routine checking, while perceptions of useful feedback and conceptual support may be more closely aligned with successful mathematical work. Findings from educational technology and feedback research support carefully designed integration rather than unsupervised repetition (Cheung & Slavin, 2013; Hattie & Timperley, 2007; Sung et al., 2016). Additional learner characteristics, instructional practices, and the limitations of self-reporting may also contribute to the observed associations.

Research-based proposed action plan

The thesis proposed strengthening the school's existing Math Mentor Xpress Club as a platform for structured peer tutorials supported by mathematics applications, including Desmos, Khan Academy, and GeoGebra. The plan targeted application-supported problem solving, error checking, conceptual exploration, and systematic monitoring. It was a proposed output of the research, not an intervention tested for impact within the study. The six action areas and original budget allocations are summarized below.

Table 6. *Proposed Math Mentor Xpress mobile-assisted action plan*

Action area	Core activity	Time frame	Budget (PHP)
Club tutorial launch	Orient members; arrange peer-tutor pairs	Week 1, Term 2	6,000
Structured peer mentoring	Guided app tasks and mentoring logs	Term 2	8,000
Accuracy and efficiency	Paired problems; handwritten solutions first	Term 3	10,000
Verification and correction	Peer error analysis and guided checking	Term 3	5,000
Interactive conceptual exploration	Graphs, functions, and inquiry tasks	Terms 2–3	4,000
Monitoring and evaluation	Attendance, surveys, grade trends and reports	End of each term	3,000

The plan creates opportunities for peers and teachers to connect the convenience of digital tools with written reasoning, error analysis, and discussion. This structure reflects the original study's recommendation to focus on meaningful learning processes while monitoring whether the proposed activities become feasible and educationally useful in practice (Bandura, 1977; Schunk & DiBenedetto, 2020; Vygotsky, 1978).

CONCLUSION

Among 220 Grade 11 learners, Desmos, Khan Academy, and Gauthmath were prominent mathematics learning applications. Overall application use was high, and students generally considered the applications effective, especially for checking solutions and correcting errors. Learners' General Mathematics performance was very satisfactory on average. The study reported no significant relationship between overall extent of use and grades, but a weak positive, significant relationship between perceived application effectiveness and grades. These findings indicate that the nature and perceived usefulness of digital support warrant more attention than frequency of use alone. Because the design was cross-sectional and correlational, causal improvement in mathematical literacy or academic performance cannot be claimed. The research contributes local evidence for more structured, curriculum-aligned mobile learning support, subject to verification of the flagged statistical entries.

Recommendation

School administrators and General Mathematics teachers should consider the proposed Math Mentor Xpress peer-tutoring program as an opportunity to organize guided application-supported learning rather than to encourage indiscriminate use of digital tools. Sessions should prioritize explaining mathematical reasoning, visualizing relationships, completing handwritten solutions, and checking errors with applications such as Desmos, Khan Academy, and GeoGebra. Peer tutors should receive orientation on appropriate tool selection, the limits of automated answers, and formative feedback.

The Mathematics Department should review the feasibility of the proposed timelines and budgets, ensure equitable access to devices and connectivity, and monitor participation, task completion, and mathematics performance if the plan is implemented. Future researchers may use longitudinal, experimental, or quasi-experimental designs to examine actual learning gains, incorporate independently assessed mathematical literacy, and account for additional factors such as prior achievement, technology access, and self-regulated learning. Before publication, the original SPSS output should be revisited to resolve the reported inconsistent correlation entries.

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