International Journal of Research Studies in Education
2026 Volume 15 Number 20, 37-54

Activity-based electronic strategic intervention material for Grade 9 students' problem solving in oblique triangles: A quasi-experimental study

Altez, Florence B. ✉
Don Mariano Marcos Memorial State University, Philippines (faltez@dmmmsu.edu.ph)

ISSN: 2243-7703
Online ISSN: 2243-7711

OPEN ACCESS

Received: 9 August 2026 **Revised**: 19 August 2026 **Accepted**: 21 August 2026
Available Online: 22 August 2026 **DOI**: 10.5861/ijrse.2026.26385

Abstract

This study examined the effectiveness of an Activity-Based Electronic Strategic Intervention Material (E-SIM) in improving Grade 9 students' problem-solving performance in solving oblique triangles. A quasi-experimental, non-equivalent group pretest-posttest control-group design was employed with 40 Grade 9 students from a public secondary school in Candon City, Philippines. Twenty students received the Activity-Based E-SIM, while 20 students received conventional paper-based remediation addressing the same competency. The intervention integrated guided learning activities, interactive tasks, multimedia resources, practice exercises, assessment activities, enhancement tasks, and reference materials designed to support the application of the Law of Sines and Law of Cosines. A researcher-developed 72-point problem-solving assessment was administered before and after the intervention. Descriptive statistics, paired-samples t tests, an independent-samples t test of gain scores, and analysis of covariance (ANCOVA) were used to examine within- and between-group differences. Both groups demonstrated significant improvement from pretest to posttest: the control group increased from $M = 18.20$ to $M = 61.10$, $t(19) = 35.22$, $p < .001$, while the experimental group increased from $M = 18.10$ to $M = 63.00$, $t(19) = 36.86$, $p < .001$. Although the experimental group obtained a greater mean gain (44.90) than the control group (42.90), the difference was not statistically significant, $t(38) = 1.16$, $p = .253$, $d = 0.37$. Similarly, ANCOVA showed no significant adjusted posttest difference between groups, $F(1, 37) = 1.31$, $p = .261$. The findings indicate that both instructional conditions were associated with substantial improvement, but the study did not establish a statistically significant advantage of the Activity-Based E-SIM over conventional remediation. The study highlights the potential of activity-based electronic materials as supplementary resources for competency-focused mathematics remediation while emphasizing the importance of instructional alignment, structured practice, and appropriate comparison conditions.

Keywords: activity-based learning, electronic strategic intervention material, E-SIM, mathematical problem solving, oblique triangles, trigonometry, Grade 9 mathematics

Activity-based electronic strategic intervention material for Grade 9 students' problem solving in oblique triangles: A quasi-experimental study

1. Introduction

Mathematical problem solving is a fundamental component of mathematics education because it requires learners to move beyond the recall of formulas and procedures toward the interpretation, representation, analysis, and application of mathematical ideas in unfamiliar situations. In solving mathematical problems, learners are expected to understand the information presented, determine the relationships among known and unknown quantities, select appropriate strategies, perform mathematical procedures accurately, and evaluate the reasonableness of their solutions. These processes become particularly demanding when mathematical concepts require learners to integrate conceptual understanding with procedural knowledge. Consequently, learners who have difficulty connecting mathematical concepts to appropriate solution strategies may continue to experience difficulties even when they can recall individual formulas or computational procedures.

This challenge is evident in geometry and trigonometry, where mathematical problem solving requires learners to interpret diagrams, identify relationships among quantities, select appropriate mathematical principles, and carry out multistep procedures. Problems involving oblique triangles are particularly demanding because learners must determine the appropriate application of the Law of Sines or Law of Cosines based on the information given. Solving such problems therefore requires more than formula substitution. Learners need to recognize the structure of the problem, identify the given and required quantities, determine the appropriate mathematical relationship, execute the solution accurately, and interpret the resulting answer. Difficulty in any of these processes may prevent learners from successfully solving oblique-triangle problems.

The need for targeted instructional intervention becomes particularly important when learners demonstrate persistent difficulty with specific competencies. Strategic Intervention Materials (SIMs) have been developed as focused instructional resources intended to address competencies that learners have not adequately mastered through regular classroom instruction. The use of intervention materials allows teachers to provide learners with additional opportunities to revisit difficult concepts, engage in guided activities, practice essential skills, and receive reinforcement. In this sense, intervention materials serve not simply as additional worksheets but as structured instructional support responsive to identified learning needs.

The literature provided for this study demonstrates the potential of intervention materials in addressing learning difficulties across different educational contexts. Rosal et al. (2022) examined an electronic strategic intervention material (E-SIM) for least-mastered competencies in General Chemistry and demonstrated the potential of an electronic intervention format as a targeted learning resource. Similarly, Manlapig et al. (2024) examined the use of E-SIM in Physics and reported improvements in learners' academic performance and motivation. These studies suggest that electronic intervention materials can provide learners with additional opportunities to engage with difficult competencies through a technology-supported learning environment. However, evidence from these studies also indicates that the effectiveness of an intervention material should be considered in relation to its instructional design and the particular learning needs it is intended to address.

The potential of intervention materials is also reflected in studies involving mathematics learning. The literature provided for the present study includes research demonstrating the value of targeted and structured instructional materials in improving learners' mathematical performance and addressing least-mastered competencies. Such findings are particularly relevant because mathematics difficulties are often competency-specific. A learner may demonstrate satisfactory performance in one mathematical domain while experiencing substantial difficulty in another. Consequently, interventions designed around specific learning gaps may provide more focused support than generalized remediation.

Beyond the provision of additional learning materials, the nature of the activities embedded in an intervention is important. Activity-based approaches provide learners with opportunities to engage directly with learning tasks rather than simply receive information from the teacher or instructional material. In mathematics, meaningful activities can encourage learners to examine mathematical relationships, make decisions, test procedures, practice strategies, and apply concepts to problems. The studies provided for this research indicate that activity-based and technology-supported learning approaches can contribute to learners' engagement and mathematical development when instructional activities are deliberately aligned with intended learning outcomes.

This consideration is particularly relevant to electronic learning materials. The use of technology alone does not necessarily guarantee improved learning. An electronic material may simply reproduce a printed lesson in digital form without substantially changing the learning experience. The pedagogical value of an E-SIM depends on whether its digital features create meaningful opportunities for learners to interact with content, practice skills, receive feedback, revisit difficult concepts, and apply their learning. Thus, the distinction between a merely digitized instructional material and an intentionally designed electronic intervention material is important. The former primarily changes the format of presentation, whereas the latter can use digital affordances to structure learners' engagement with the learning process.

The literature supplied for this study provides support for this broader view of technology-enhanced learning. Hori et al. (2025) examined digital applications in learning and highlighted the role of technology-supported learning experiences in facilitating student learning. Ingebrigtsen et al. (2025) examined teacher-created digital learning materials, emphasizing the relevance of teacher-developed digital resources to instructional practice. Aligo and Prudente (2025) and Wang et al. (2026) further provide evidence concerning the contribution of digital and technology-enhanced learning environments to educational outcomes. Collectively, these studies suggest that digital instructional resources can provide meaningful learning opportunities, although their effectiveness depends on the quality, purpose, and pedagogical organization of the learning experiences they provide.

In mathematics education, this issue becomes particularly significant because mathematical understanding develops through active engagement with mathematical ideas and problems. Zhidkikh et al. (2023), Santos (2026), Kayaalp et al. (2026), and Adam et al. (2026), as reflected in the literature base of the present study, provide evidence concerning technology-supported approaches to mathematics and learning. These studies support the potential of technology to facilitate mathematical engagement and learning, but they also point to the importance of purposeful instructional design. Digital tools become educationally meaningful when they are connected to activities through which learners are required to think, practice, reason, and apply mathematical concepts.

The activity-based orientation of the present intervention is also supported by the studies included in the literature base. Yüksel (2014), Bairy and Inamdar (2026), and Sattabut and Phusee-orn (2026) provide evidence concerning activity-oriented approaches to learning and mathematics instruction. Their findings reinforce the importance of engaging learners in structured activities that allow them to participate actively in the learning process. For mathematical problem solving, such an approach is particularly relevant because learners need opportunities to repeatedly practice the processes involved in understanding and solving problems rather than simply observe worked examples.

The relationship between activity, problem solving, and mathematical thinking is further supported by the literature on metacognition and mathematical problem solving. Susanna et al. (2026) and Liu et al. (2026) highlight the importance of learners' cognitive and metacognitive processes in mathematical problem solving, while Chehlarova et al. (2025) provides further evidence concerning mathematical thinking and problem-solving processes. These studies suggest that effective mathematical learning involves not only knowing mathematical procedures but also making decisions about how and when those procedures should be applied. An intervention intended to improve problem-solving performance should therefore provide learners with opportunities to engage repeatedly with problems, examine solution strategies, and develop greater control over the mathematical processes involved.

Trigonometry provides an especially appropriate context for such an intervention. Karjanto (2011) and Glassmeyer et al. (2019), among the studies included in the present literature base, provide relevant perspectives concerning mathematical understanding and the learning of mathematical concepts associated with trigonometry and reasoning. The application of trigonometric principles to oblique triangles requires learners to connect mathematical representations with appropriate procedures. Learners must determine whether the Law of Sines or Law of Cosines is applicable, identify the relevant sides and angles, substitute values correctly, perform calculations, and interpret the result. These demands make oblique-triangle problem solving an appropriate context for an intervention that emphasizes guided activities, repeated practice, and structured problem-solving engagement.

The literature also indicates that learner engagement and motivation may influence the effectiveness of technology-supported instructional interventions. Kalay and Arıkan (2023) and Cetin et al. (2026), together with Hori et al. (2025) and Zhidkikh et al. (2023), provide evidence concerning the relationship between technology-supported or interactive learning experiences and learners' engagement with learning. These findings are relevant to the present study because intervention materials are more likely to provide meaningful learning opportunities when learners actively interact with the material. An activity-based E-SIM can potentially support such interaction by incorporating multimedia explanations, guided tasks, interactive exercises, quizzes, practice activities, and opportunities for reinforcement.

Taken together, the supplied literature suggests three important points. First, strategic intervention materials can provide targeted support for learners experiencing difficulty with specific competencies. Second, electronic and technology-enhanced learning materials can expand the ways in which learners interact with instructional content. Third, activity-based and problem-oriented learning approaches can provide opportunities for learners to actively practice mathematical processes and develop problem-solving skills. However, these strands of literature have generally examined these dimensions in different combinations, learning areas, or contexts. The novelty of the present study lies in examining an activity-based electronic strategic intervention material specifically designed for Grade 9 mathematical problem solving involving oblique triangles and in comparing its outcomes with conventional competency-focused remediation. Rather than assuming that digital delivery is inherently superior, the study empirically examines whether integrating electronic affordances with structured mathematical activities provides an observable advantage over an active conventional intervention.

1.1 Research Gap

Despite the growing body of research on intervention materials, digital learning, activity-based instruction, and mathematical problem solving, a more specific gap remains. The literature supplied for the present study provides evidence on E-SIMs in learning areas such as Chemistry and Physics, research on digital learning materials, studies of activity-based mathematics learning, and investigations of mathematical problem-solving processes. However, there is comparatively limited evidence concerning the combined use of an activity-based E-SIM as a targeted intervention for a specific Grade 9 mathematics competency involving oblique-triangle problem solving. The gap is therefore not simply the absence of research on electronic learning materials or mathematics technology. Rather, it lies in the intersection of electronic strategic intervention, activity-based learning, and mathematical problem solving within a specific secondary-school trigonometry competency. In particular, the available literature provides limited evidence on whether a digitally delivered intervention intentionally organized around interactive and activity-based learning experiences can improve learners' ability to solve problems involving oblique triangles. This gap is important because the difficulty associated with oblique-triangle problems is not necessarily resolved by providing learners with additional explanations or copies of formulas. Learners must develop the ability to recognize problem structures, determine appropriate mathematical relationships, select and apply the Law of Sines or Law of Cosines, carry out the necessary procedures, and interpret their answers. An intervention that incorporates activities specifically designed around these processes may therefore provide a more targeted response to the learning difficulty.

1.2 Context and Rationale of the Present Study

The present study was developed in response to an identified learning need among Grade 9 learners in the study setting. The competency "Solve problems involving oblique triangles" (M9GE-IVh-j-1) was identified as a least-mastered competency, with learners demonstrating difficulty in applying the appropriate trigonometric principles to problem situations. This learning difficulty provided the basis for developing an intervention specifically focused on oblique-triangle problem solving rather than general mathematics achievement. The intervention was designed as an Activity-Based Electronic Strategic Intervention Material (E-SIM). It incorporated electronic and interactive learning resources intended to provide learners with structured opportunities to engage with the target competency. The intervention was organized around activities, guided practice, assessment, enhancement, and reference materials, thereby allowing learners to encounter mathematical ideas, practice their application, assess their understanding, and reinforce previously learned concepts. The study consequently does not treat technology as an end in itself. Instead, the E-SIM was conceived as a pedagogical tool through which activity-based learning could be organized around a specific mathematical learning gap. The central proposition is that when electronic resources are intentionally aligned with mathematical activities and problem-solving processes, they may provide learners with additional opportunities to practice and strengthen the skills required to solve complex mathematical problems.

1.3 Novelty and Contribution of the Study

The distinctive contribution of the present study lies in its integration of three instructional dimensions: electronic strategic intervention materials, activity-based learning, and mathematical problem solving. While the literature supplied for the study demonstrates the potential of these approaches individually or in different combinations, the present investigation focuses specifically on their integration in addressing Grade 9 learners' difficulty in solving oblique triangles. The study therefore contributes to the literature in two ways. First, it provides empirical evidence concerning an E-SIM designed for a specific secondary mathematics competency, rather than examining digital learning outcomes in mathematics at a general level. Second, it demonstrates an instructional design in which the electronic format is intentionally combined with activities that require learners to engage with mathematical problems, practice solution procedures, and apply the Law of Sines and Law of Cosines. Thus, the innovation of the study is not simply that the intervention is electronic. Its innovation lies in the alignment of the electronic environment with activity-based mathematical problem solving. This distinction is important because the effectiveness of digital learning should be understood in terms of how technology supports meaningful learning activities rather than merely replacing printed instructional materials.

1.4 Purpose of the Study

Anchored in this gap and rationale, the present study examined the impact of an Activity-Based Electronic Strategic Intervention Material (E-SIM) on the problem-solving skills of Grade 9 students in solving oblique triangles. Specifically, it sought to determine whether learners exposed to the Activity-Based E-SIM demonstrated improved problem-solving performance compared with learners who received conventional remediation for the same competency. The study contributes to mathematics education by providing evidence concerning a targeted, technology-supported intervention for learners experiencing difficulty with a specific trigonometric competency. Its findings may inform mathematics teachers in designing remediation activities, assist schools in developing technology-supported learning resources, and provide a basis for further research on the use of activity-based electronic intervention materials to address specific learning gaps in mathematics.

1.5 Research Questions

This study aimed to determine the effectiveness of an Activity-Based Electronic Strategic Intervention Material (E-SIM) in improving the problem-solving skills of Grade 9 students in solving oblique triangles. Specifically, it sought to answer the following questions:

1. What is the level of problem-solving performance of the experimental and control groups in solving oblique triangles before the intervention?

2. What is the level of problem-solving performance of the experimental and control groups in solving oblique triangles after the intervention?

3. Is there a significant difference between the pretest and posttest problem-solving performance of the experimental group exposed to the Activity-Based E-SIM?

4. Is there a significant difference between the pretest and posttest problem-solving performance of the control group exposed to the conventional remediation approach?

5. Is there a significant difference in the posttest problem-solving performance between students exposed to the Activity-Based E-SIM and those exposed to the conventional remediation approach?

6. What is the magnitude of the effect of the Activity-Based E-SIM on students' problem-solving performance in solving oblique triangles?

2. Theoretical Framework

The present study is anchored on the proposition that learners' mathematical problem-solving performance can be strengthened when instructional interventions provide targeted content, active engagement, repeated practice, opportunities for feedback, and structured interaction with mathematical problems. The Activity-Based Electronic Strategic Intervention Material (E-SIM) developed in this study brings these elements together in a digital learning environment specifically designed to address learners' difficulty in solving problems involving oblique triangles. Activity-based learning explains the nature of learner engagement; technology-enhanced learning explains the affordances of the electronic medium; and the metacognitive perspective explains the strategic processes involved in mathematical problem solving.

Activity-Based Learning Perspective - The first theoretical anchor is the activity-based learning perspective, which emphasizes learning through purposeful participation in activities rather than through passive reception of information. The studies included in the present literature base, particularly Yüksel (2014), Bairy and Inamdar (2026), and Sattabut and Phusee-orn (2026), provide support for the use of activity-oriented approaches in mathematics learning. Within this perspective, mathematical learning occurs through learners' engagement with tasks that require them to examine relationships, apply concepts, make decisions, perform procedures, and solve problems. The learner is therefore not merely a recipient of mathematical information but an active participant in constructing and applying mathematical understanding.

This perspective is particularly relevant to the present study because solving oblique-triangle problems requires learners to engage in a sequence of purposeful mathematical activities. Learners must identify the information given, determine the required quantity, recognize the structure of the problem, select the appropriate trigonometric law, perform the necessary calculations, and interpret the solution. An activity-based intervention can provide repeated opportunities for learners to practice these processes in a structured manner. The Activity-Based E-SIM operationalizes this perspective by incorporating guided activities, interactive exercises, practice tasks, assessment activities, and enhancement exercises. Thus, the electronic material is not intended merely to present information about the Law of Sines and Law of Cosines. Rather, it provides a structured sequence through which learners can engage with, practice, apply, and reinforce the target mathematical competency.

Technology-Enhanced Learning Perspective - The second theoretical anchor is the technology-enhanced learning perspective, supported by the studies in the supplied literature concerning digital learning materials and technology-supported instruction. Hori et al. (2025), Ingebrigtsen et al. (2025), Aligo and Prudente (2025), Wang et al. (2026), Zhidkikh et al. (2023), Santos (2026), Kayaalp et al. (2026), and Adam et al. (2026) collectively provide a basis for considering technology as a means of expanding learners' opportunities to interact with instructional content. The theoretical significance of technology in the present study does not rest on the assumption that electronic materials are inherently superior to printed materials. Instead, technology is considered an instructional affordance that can facilitate forms of interaction that support the intended learning process. An electronic environment can incorporate multimedia resources, interactive tasks, digital quizzes, repeated practice, and other forms of learner engagement. These affordances can make it possible to organize intervention activities in ways that are responsive to learners' specific learning needs. This perspective is important because the E-SIM in the present study is designed around a particular mathematical competency rather than general digital learning. Its digital features are deliberately connected to the learning objectives of solving oblique triangles. Consequently, technology functions as a means of delivering and organizing purposeful mathematical activities rather than as the independent source of learning improvement.

The theoretical relationship may therefore be expressed as:

Digital affordances → meaningful learner interaction → increased opportunities for practice and feedback → strengthened engagement with mathematical tasks

This formulation is consistent with the literature emphasizing the importance of purposeful integration of technology into learning rather than technology use for its own sake.

Metacognitive Perspective on Mathematical Problem Solving - The third theoretical anchor concerns the cognitive and metacognitive dimensions of mathematical problem solving. Susanna et al. (2026), Liu et al. (2026), and Chehlarova et al. (2025) provide support for considering problem solving as a process involving more than procedural knowledge. In solving an oblique-triangle problem, learners must make strategic decisions throughout the solution process. They must determine what information is relevant, identify what is being asked, decide whether the Law of Sines or Law of Cosines is appropriate, execute the selected procedure, and examine whether the answer is mathematically reasonable. These processes require learners to monitor their understanding and regulate their solution strategies. The metacognitive perspective therefore provides an important explanation for why simply giving learners additional formulas may not be sufficient. A learner may remember both trigonometric laws but still fail to solve a problem if the learner cannot determine which law is appropriate or cannot monitor whether the selected procedure fits the problem.

The Activity-Based E-SIM addresses this dimension by providing repeated problem-solving opportunities in which learners are required to apply mathematical relationships to different situations. Through guided activities, practice, assessment, and enhancement tasks, learners are given opportunities to engage with the sequence of decisions involved in problem solving. The theoretical assumption is therefore that:

Repeated and structured engagement with mathematical problems → opportunities to practice strategic decision-making and monitoring → improved problem-solving performance

This does not imply that the E-SIM directly measures metacognition as an independent variable. Rather, the metacognitive perspective provides a theoretical explanation for the processes through which activity-based problem-solving tasks may contribute to the observed outcome.

Integration of the Theoretical Perspectives - The three perspectives are integrated into a single instructional logic.

- Activity-based learning explains what learners do: they actively engage in mathematical tasks.
- Technology-enhanced learning explains how the E-SIM provides the learning environment: digital resources organize interactive, multimedia, practice, and assessment opportunities.
- The metacognitive/problem-solving perspective explains what kind of thinking is required: learners

identify information, select strategies, apply procedures, monitor their solutions, and evaluate results.

Accordingly, the theoretical foundation of the study can be summarized as follows:

Activity-based pedagogy provides meaningful mathematical tasks; technology-enhanced learning provides an interactive electronic environment for those tasks; and metacognitive problem-solving processes explain the strategic thinking learners engage in while solving mathematical problems.

The integration of these perspectives provides the theoretical basis for expecting an activity-based E-SIM to contribute to improved performance in solving oblique-triangle problems.

2.1 Conceptual Framework

The conceptual framework presents the logical relationship among the identified learning need, the Activity-Based Electronic Strategic Intervention Material (E-SIM), the learning processes facilitated by the intervention, and students' problem-solving performance in solving oblique triangles. The framework assumes that an instructional intervention is more likely to address a specific learning difficulty when the identified competency, instructional activities, learning resources, and assessment are deliberately aligned. The identified learning need in the present study was learners' difficulty in solving problems involving oblique triangles, particularly those requiring the application of the Law of Sines and Law of Cosines. In response, the Activity-Based E-SIM was developed as a targeted electronic intervention incorporating guided activities, interactive exercises, multimedia resources, practice tasks, assessment activities, enhancement exercises, and reference materials. The framework positions the E-SIM as the intervention variable and students' problem-solving performance as the outcome variable. The intervention was expected to provide opportunities for active mathematical engagement, repeated practice, strategic decision-making, and application of mathematical procedures. Pretest performance was considered as baseline information, while posttest performance provided the basis for evaluating learning following the intervention.

The conceptual relationship may be summarized as:

Identified Learning Need → Activity-Based E-SIM → Active Mathematical Engagement, Guided Practice, and Problem-Solving Application → Problem-Solving Performance

The framework does not assume that electronic delivery automatically produces improved achievement. Rather, it proposes that the potential contribution of the E-SIM derives from the deliberate integration of digital affordances with activity-based and competency-focused mathematical learning experiences. The quasi-experimental comparison with conventional remediation provides the empirical basis for determining whether the Activity-Based E-SIM offers an advantage beyond conventional intervention.

The conceptual framework is therefore not intended to suggest a simple or automatic causal relationship between technology and achievement. Instead, it proposes that the potential contribution of the E-SIM arises from the intentional integration of electronic resources with activity-based mathematical learning experiences. The electronic format provides the medium through which learning resources and interactive activities are delivered, while the activity-based design provides opportunities for learners to actively engage with mathematical concepts and problems.

In the context of the present study, this relationship is particularly relevant because solving oblique triangles requires learners to coordinate conceptual understanding and procedural application. Learners must determine which mathematical relationship is appropriate before they can successfully execute the required computations. The E-SIM therefore provides structured opportunities for learners to repeatedly practice not only computational procedures but also the decision-making processes involved in selecting and applying the Law of Sines and Law of Cosines.

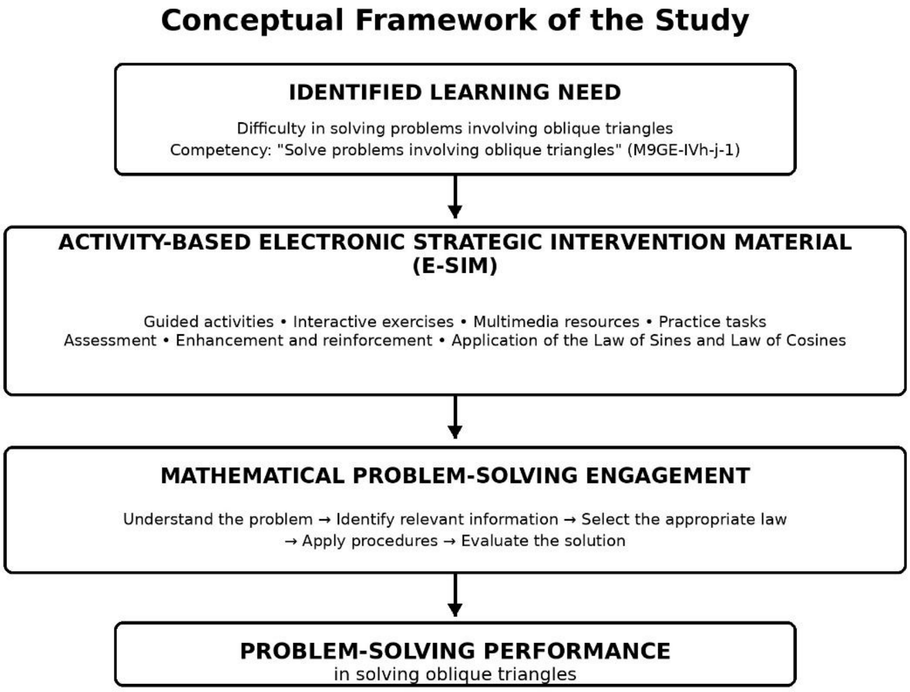

Figure 1: Conceptual Framework of the Study

The framework also recognizes the importance of alignment among learning need, intervention, and assessment. The competency identified as requiring intervention is the same competency addressed by the E-SIM and evaluated through the problem-solving assessment. This alignment strengthens the internal coherence of the study because the intervention is directly connected to the measured outcome. Accordingly, the conceptual framework establishes the following central proposition:

> *When a targeted mathematical learning difficulty is addressed through an electronic intervention material deliberately organized around activity-based learning and the problem-solving processes required by the target competency, learners may demonstrate improved performance following the intervention.*

The proposition is empirically examined by comparing the performance of learners exposed to the Activity-Based E-SIM with that of learners who receive conventional remediation, using pretest and posttest measures.

3. Methodology

Research Design - The study employed a quasi-experimental, non-equivalent pretest-posttest control-group design to examine the effectiveness of an Activity-Based Electronic Strategic Intervention Material (E-SIM) in improving Grade 9 students' problem-solving performance in solving oblique triangles. The study involved two existing Grade 9 classes with 20 students each. One class served as the experimental group and received the Activity-Based E-SIM, while the other served as the control group and received conventional paper-based remediation addressing the same competency. Both groups completed the same researcher-developed problem-solving assessment before and after the intervention. The pretest established the learners' baseline performance, while the posttest measured their performance following the respective instructional conditions. Because the participants were drawn from existing classes rather than individually randomized, the design was treated as quasi-experimental and the groups as non-equivalent.

The intervention was implemented within the regular school setting and scheduled remedial sessions. The two groups received instructional support on the same Grade 9 competency, with the principal difference being the instructional modality: an activity-based electronic intervention for the experimental group and conventional paper-based remediation for the control group. The design therefore permitted examination of changes in performance within each group and comparison of post-intervention performance between the two instructional conditions.

Research Context and Participants - The study was conducted at Candon National High School, Philippines, during School Year 2021–2022. It emerged from a school-based mathematics learning difficulty involving the Grade 9 competency "Solve problems involving oblique triangles" (M9GE-IVh-j-1), which had been identified as a least-learned competency in the school context, with an observed performance rating of 22.63%. This identified learning need provided the instructional basis for developing the Activity-Based E-SIM. The participants were 40 Grade 9 students enrolled in two existing regular classes. The participants comprised 20 male and 20 female students. Twenty students constituted the experimental group and 20 constituted the control group. The experimental group received the Activity-Based E-SIM, while the control group received conventional paper-based work exercises and assignments addressing the same target competency.

The participants were selected within the existing school class structure because they required additional instructional support in the target mathematics competency. Because the groups consisted of intact classes rather than individually randomized participants, the study is appropriately characterized as a non-equivalent group quasi-experimental study. This characteristic was considered in interpreting the findings, particularly with respect to baseline differences and the generalizability of the results. The use of intact classes also preserved the authenticity of the school-based intervention. However, it limits the extent to which the findings can be generalized beyond the participating learners and instructional setting.

Intervention: Activity-Based Electronic Strategic Intervention Material - The intervention was an Activity-Based Electronic Strategic Intervention Material (E-SIM) developed specifically to address Grade 9 students' difficulty in solving problems involving oblique triangles. The material focused on the application of the Law of Sines and Law of Cosines and was designed as an interactive digital learning resource rather than as a simple electronic reproduction of conventional printed remediation material. The E-SIM was organized into interconnected components that supported the instructional sequence. The Title Card introduced the material and identified the target competency; the Guide Card provided instructions for navigation and use; the Activity Card contained interactive activities, multimedia content, questions, and exercises; the Assessment Card provided opportunities for learners to demonstrate their understanding through problem-solving tasks; the Enhancement Card provided additional practice and reinforcement; and the Reference Card provided supporting mathematical information and resources.

The digital material was developed using Kotobee Author, while interactive activities were incorporated through Wordwall. The activities included game-based exercises, quizzes, matching activities, and other learner-response tasks. These components were intended to provide learners with repeated opportunities to interact with mathematical content and engage in problem-solving activities. The intervention was deliberately aligned with the cognitive demands of solving oblique-triangle problems. Learners were expected to identify information given in a problem, determine the quantity being sought, select an appropriate mathematical relationship, apply the Law of Sines or Law of Cosines, perform the necessary calculations, and interpret their results. The activity-based organization therefore provided repeated opportunities for learners to practice both conceptual and procedural aspects of mathematical problem solving. An accompanying user manual provided instructions for downloading, installing, navigating, and using the E-SIM. An orientation was conducted one week before the intervention to familiarize learners with the digital material and its procedures. The intervention was subsequently implemented during scheduled remedial sessions.

Control Condition - The control group received conventional paper-based remediation addressing the same Grade 9 competency and mathematical content covered by the experimental intervention. Learners worked with traditional exercises and assignments focused on solving problems involving oblique triangles through the application of the Law of Sines and Law of Cosines. The control condition was implemented during the same remedial period as the Activity-Based E-SIM intervention. Thus, both groups received additional instructional support directed toward the same learning target, while the principal instructional distinction was the use of the activity-based digital environment in the experimental condition. This arrangement provided a basis for examining whether embedding mathematical tasks within the Activity-Based E-SIM offered additional learning benefits beyond conventional paper-based remediation.

Research Instrument - A researcher-developed mathematical problem-solving assessment was used to measure students' performance in solving problems involving oblique triangles. The assessment was aligned with the target Grade 9 competency, "Solve problems involving oblique triangles" (M9GE-IVh-j-1), and covered applications of both the Law of Sines and Law of Cosines. The assessment consisted of six contextualized problem-solving items, with each item having a maximum score of 12 points and the complete assessment having a maximum possible score of 72 points. The tasks required learners to interpret mathematical situations, identify relevant information, select an appropriate solution strategy, perform mathematical procedures, and interpret the resulting answer.

An analytic scoring rubric was used to evaluate learners' solutions across four dimensions: (a) defining the problem, (b) developing a plan to solve the problem, (c) solving the problem, and (d) interpreting findings. Each dimension was scored on a three-point scale, with 3 representing high performance, 2 representing adequate performance, and 1 representing limited performance. Thus, each item had a maximum score of 12 points (4 dimensions × 3 points), resulting in a total possible score of 72 points across the six items. The assessment was designed to capture the process of mathematical problem solving, rather than merely the correctness of the final numerical answer. The scoring framework therefore considered learners' ability to define the problem, formulate an appropriate solution plan, execute the mathematical procedures, and interpret the result. For descriptive interpretation, total scores were classified into five performance levels: Needs Improvement (0–14.40), Poor Skill (14.41–28.80), Good Skill (28.81–43.20), Very Good Skill (43.21–57.60), and Excellent Skill (57.61–72.00). These categories were used to describe learners' overall problem-solving performance before and after the intervention.

Validation of the Research Instrument and E-SIM - The researcher-developed assessment and the Activity-Based E-SIM underwent expert review before implementation. The assessment was reviewed by two master teachers and the head teacher of the Mathematics Department, while the E-SIM was reviewed by personnel with expertise in mathematics, educational technology, quality assurance, and instructional supervision. The expert review examined the alignment of the assessment and intervention material with the target competency, appropriateness and accuracy of the mathematical content, clarity of instructions, suitability for Grade 9 learners, and consistency between the learning activities and intended learning objectives. Revisions were made based on the feedback obtained before implementation.

Data Collection Procedure - The study followed a sequential protocol consisting of preparation and permission, participant orientation, pretesting, intervention implementation, posttesting, and data analysis. First, the researcher secured the necessary permission from the school and coordinated the implementation with the concerned personnel. The Activity-Based E-SIM and the researcher-developed problem-solving assessment were subjected to expert review and were revised based on the recommendations received before implementation. Second, the experimental-group learners were oriented on the use of the Activity-Based E-SIM one week before the intervention. The orientation familiarized learners with accessing the material, navigating its components, and completing the activities. This preliminary orientation was intended to minimize difficulties arising from unfamiliarity with the digital material during the intervention. Third, both the experimental and control groups completed the pretest before the intervention. The assessment measured their baseline performance in solving problems involving oblique triangles, particularly problems requiring the application of the Law of Sines and Law of Cosines.

Fourth, the experimental group underwent the Activity-Based E-SIM intervention during the designated remedial sessions. The learners worked through the electronic material and completed its activity-based learning tasks, including interactive exercises, questions, quizzes, matching activities, and other practice tasks related to solving oblique triangles. The material provided opportunities for learners to identify problem information, select appropriate solution strategies, perform mathematical procedures, and interpret their solutions. During the corresponding intervention period, the control group received conventional paper-based remediation covering the same target competency. The learners completed traditional exercises and assignments involving the solution of oblique-triangle problems using the Law of Sines and Law of Cosines. Fifth, after completion of the intervention, both groups completed the posttest using the designated problem-solving assessment. The responses were scored using the predetermined analytic scoring rubric covering problem definition, solution planning, problem solving, and interpretation of findings. Finally, the pretest and posttest scores were encoded and analyzed using descriptive and inferential statistical procedures. Mean and standard deviation were used to summarize performance, while appropriate statistical tests were used to examine within-group changes and between-group differences. Because the study employed non-equivalent groups, the posttest comparison was also examined while accounting for baseline performance.

Ethical Considerations - Administrative permission to conduct the study was secured from the appropriate school authorities before data collection. Because the participants were Grade 9 students and therefore minors, informed consent was obtained from their parents or legal guardians, and assent was obtained from the participating students before their inclusion in the study. Participants and their parents or guardians were informed of the purpose and procedures of the study, the voluntary nature of participation, the confidentiality of the information collected, and the right to withdraw without academic penalty. Participant identities were protected through the use of coded data, and results were reported only in aggregate form. The control group received conventional remediation addressing the same target competency, ensuring that participation did not involve withholding necessary instructional support.

Data Analysis - The data were analyzed using descriptive and inferential statistical procedures. Mean (M) and standard deviation (SD) were used to summarize students' pretest and posttest performance on the 72-point problem-solving assessment. Mean gain scores were computed by subtracting the pretest mean from the corresponding posttest mean to describe the observed improvement within each instructional condition. An independent-samples t test was first used to examine whether the experimental and control groups differed significantly in their pretest performance. This analysis provided an assessment of baseline comparability prior to the intervention. Paired-samples t tests were then used separately for the experimental and control groups to determine whether students' problem-solving performance changed significantly from pretest to posttest.

To examine the difference in improvement between the two instructional conditions, an independent-samples t test was conducted on the gain scores. Cohen's d was calculated to estimate the standardized magnitude of the between-group difference in gain scores. Because the study employed intact, non-equivalent groups, an analysis of covariance (ANCOVA) was additionally conducted to compare posttest performance between the experimental and control groups while controlling for pretest performance. Posttest score served as the dependent variable, instructional condition as the independent variable, and pretest score as the covariate. The assumptions relevant to ANCOVA, including linearity, homogeneity of regression slopes, independence of observations, and the distribution of residuals, were considered before interpreting the adjusted group effect. All inferential tests were evaluated at the .05 level of significance.

4. Results

4.1 Pretest Performance of the Experimental and Control Groups

The first research question determined the level of students' problem-solving performance in solving oblique triangles before the intervention. The control group obtained a pretest mean of 18.20 (SD = 3.72), while the experimental group obtained a pretest mean of 18.10 (SD = 3.58), based on a maximum possible score of 72. An independent-samples t test showed that the difference between the pretest scores of the two groups was not statistically significant, t (38) = 0.09, $p = .931$. Thus, the two groups demonstrated comparable problem-solving performance before the intervention.

Table 1

Pretest and Posttest Problem-Solving Performance of the Control and Experimental Groups

Group	Pretest *M*	Pretest *SD*	Posttest *M*	Posttest *SD*	Mean Gain
Control (n = 20)	18.20	3.72	61.10	6.56	42.90
Experimental (n = 20)	18.10	3.58	63.00	5.96	44.90

Note. M = mean; *SD* = standard deviation. The maximum possible score was 72.

The pretest results indicate that the groups started the intervention with nearly identical mean performance. The difference between the two pretest means was only **0.10 point**, providing no statistical evidence of a baseline difference between the groups.

4.2 Posttest Performance of the Experimental and Control Groups

The second research question determined the level of students' problem-solving performance after the intervention. The control group obtained a posttest mean of 61.10 (SD = 6.56), while the experimental group obtained a higher posttest mean of 63.00 (SD = 5.96). Both groups therefore demonstrated substantial improvement from their respective pretest performance. Descriptively, the experimental group obtained a posttest mean that was 1.90 points higher than that of the control group. However, the higher posttest mean of the experimental group should not, by itself, be interpreted as evidence that the E-SIM was statistically more effective than conventional remediation. The comparative effectiveness of the two interventions was examined through the subsequent inferential analyses.

4.3 Pretest-to-Posttest Performance of the Control Group

The third research question examined whether there was a significant difference between the pretest and posttest performance of the control group. The control group's mean performance increased from 18.20 (SD = 3.72) in the pretest to 61.10 (SD = 6.56) in the posttest, corresponding to a mean gain of 42.90 points. A paired-samples t test indicated that this increase was statistically significant, t (19) = 35.22, $p < .001$. Thus, students who received conventional paper-based remediation demonstrated a statistically significant improvement in their problem-solving performance following the intervention period.

4.4 Pretest-to-Posttest Performance of the Experimental Group

The fourth research question examined whether there was a significant difference between the pretest and posttest performance of students exposed to the Activity-Based E-SIM. The experimental group's mean performance increased from 18.10 (SD = 3.58) in the pretest to 63.00 (SD = 5.96) in the posttest. This represented a mean gain of 44.90 points. A paired-samples t test showed that the increase in performance was statistically significant, t(19) = 36.86, $p < .001$. Therefore, students exposed to the Activity-Based E-SIM demonstrated a statistically significant improvement in their problem-solving performance from pretest to posttest. The magnitude of the improvement was substantial in descriptive terms, with the group's average score increasing by 44.90 points on the 72-point assessment.

4.5 Difference in Improvement Between the Experimental and Control Groups

The fifth research question determined whether the improvement in problem-solving performance differed significantly between the experimental and control groups. The experimental group obtained a mean gain of 44.90 points, compared with 42.90 points for the control group. Thus, the experimental group demonstrated a 2.00-point greater mean gain than the control group. However, an independent-samples t test of the gain scores indicated that the difference was not statistically significant, t (38) = 1.16, p = .253. The corresponding Cohen's d was 0.37, representing a small effect. Therefore, although the descriptive gain favored the Activity-Based E-SIM, the difference in improvement between the two groups did not reach statistical significance.

4.6 Adjusted Comparison of Posttest Performance

Given the quasi-experimental design and the use of intact groups, the sixth research question was further examined using analysis of covariance (ANCOVA). Posttest performance was treated as the dependent variable, instructional condition as the independent variable, and pretest performance as the covariate. After controlling for pretest performance, the difference in adjusted posttest performance between the experimental and control groups was not statistically significant, F (1, 37) = 1.31, p = .261. The overall model explained approximately 26.9% of the variance in posttest performance (R^2 = .269). The ANCOVA result therefore provides additional evidence that the higher posttest performance of the experimental group was not statistically distinguishable from that of the control group after accounting for baseline performance.

4.7 Summary of Findings

Overall, the results demonstrate substantial improvement in problem-solving performance among students in both instructional conditions. The control group increased from a mean of 18.20 to 61.10, while the experimental group increased from 18.10 to 63.00. Both within-group improvements were statistically significant. Although the experimental group achieved a slightly higher posttest mean and a slightly greater mean gain than the control group, the 2.00-point difference in mean gain was not statistically significant. The small effect size (d = 0.37) and the non-significant ANCOVA result, F (1, 37) = 1.31, p = .261, likewise do not provide sufficient evidence to conclude that the Activity-Based E-SIM was statistically superior to conventional remediation. Accordingly, the findings support the conclusion that both the Activity-Based E-SIM and conventional paper-based remediation were associated with significant improvement in students' problem-solving performance in solving oblique triangles. However, within the conditions of this study, the evidence does not establish a statistically significant advantage of the Activity-Based E-SIM over the conventional approach.

5. Discussion

The findings indicate that both the Activity-Based Electronic Strategic Intervention Material (E-SIM) and conventional paper-based remediation were associated with substantial improvement in Grade 9 students' problem-solving performance in solving oblique triangles. The two groups began with nearly equivalent pretest performance, with mean scores of 18.20 for the control group and 18.10 for the experimental group. The absence of a significant baseline difference suggests that the groups were reasonably comparable on the measured outcome before the intervention.

Students who received the Activity-Based E-SIM demonstrated a statistically significant increase in problem-solving performance from pretest to posttest. Their mean score increased from 18.10 to 63.00, representing a mean gain of 44.90 points. This finding suggests that the intervention provided learners with substantial opportunities to engage with the target competency and practice the processes involved in solving oblique-triangle problems. The activity-based organization of the E-SIM required learners to interact with mathematical content, work through guided tasks, complete practice activities, and apply the Law of Sines and Law of Cosines to problem situations. This pattern is consistent with the literature emphasizing the potential value of activity-oriented and technology-supported learning environments in supporting mathematical engagement and learning.

However, the improvement observed in the control group is equally important. Students receiving conventional paper-based remediation increased their mean score from 18.20 to 61.10, corresponding to a mean gain of 42.90 points. This improvement was also statistically significant. Because both groups received focused remediation addressing the same competency, the finding indicates that competency-focused practice and structured remediation may themselves have contributed substantially to learning. The result therefore cautions against attributing improvement exclusively to the electronic format of the experimental intervention.

Although the experimental group obtained a slightly higher posttest mean and a 2.00-point greater mean gain than the control group, the difference was not statistically significant, t (38) = 1.16, p = .253, with a small standardized effect (d = 0.37). ANCOVA likewise showed no statistically significant adjusted posttest difference after controlling for pretest performance, F (1, 37) = 1.31, p = .261. Thus, the present evidence does not establish that the Activity-Based E-SIM was superior to conventional remediation.

This finding is important in interpreting technology-supported instruction. The educational value of an electronic material should not be attributed to its digital format alone. Rather, its potential value depends on how technological features are connected to learning objectives, learner activities, practice opportunities, and feedback. The Activity-Based E-SIM in the present study was deliberately designed to combine digital resources with structured mathematical activities. Nevertheless, the control group also received targeted practice addressing the same competency. The similarity in improvement between the two groups suggests that the focused instructional experience common to both conditions may have been an important contributor to learning.

The findings are also consistent with the broader literature reviewed in the study concerning electronic strategic intervention materials. Research on E-SIMs in General Chemistry and Physics has reported improvements associated with electronic intervention materials, demonstrating their potential as supplementary instructional resources (Manlapig et al., 2024; Rosal et al., 2022). The present study extends this line of inquiry to secondary mathematics and, more specifically, to problem solving involving oblique triangles. Importantly, however, the present findings also demonstrate why evidence of improvement within an E-SIM group should be distinguished from evidence of superiority over another active instructional condition.

The results further support the relevance of activity-based approaches to mathematics learning. Solving oblique-triangle problems requires learners to interpret information, identify the required quantity, select an appropriate mathematical relationship, apply mathematical procedures, and evaluate the resulting answer. Activity-oriented instruction can provide opportunities for learners to repeatedly practice these processes rather than simply memorize formulas. The literature included in the study similarly emphasizes the importance of active engagement, purposeful activities, and problem-solving processes in mathematical learning.

The findings may also be interpreted from a metacognitive perspective. Successful solution of an oblique-triangle problem requires strategic decisions concerning which mathematical law should be applied and whether the resulting procedure and answer are appropriate. The Activity-Based E-SIM provided repeated opportunities to engage in such problem-solving processes. However, because metacognition was not directly measured in the present study, the study should not claim that the intervention improved metacognitive skills. Rather, metacognitive processes provide a theoretical explanation for the types of thinking potentially activated through the intervention.

From a practical perspective, the findings suggest that the Activity-Based E-SIM may be used as a supplementary remediation resource rather than as a replacement for conventional remediation. Its value lies in providing teachers with another way of organizing targeted mathematical practice, particularly where digital resources are accessible. For learners, the electronic format may provide additional opportunities to revisit explanations, practice procedures, and engage with interactive activities. For teachers and schools, the material may serve as an additional resource for addressing identified least-mastered competencies.

Overall, the findings provide a nuanced contribution to the literature. The Activity-Based E-SIM was associated with substantial improvement in students' problem-solving performance, but its improvement was not statistically greater than that produced by conventional remediation. The results therefore support the potential usefulness of activity-based electronic intervention materials while emphasizing that their effectiveness should be evaluated in relation to instructional design, the quality of learning activities, implementation conditions, and the nature of the comparison condition.

Practical Educational Implications - The findings have practical implications for mathematics teachers, students, school leaders, and learning-resource developers. For mathematics teachers, the results suggest that remediation should be anchored in clearly identified learning gaps and should provide learners with repeated opportunities to apply mathematical concepts through structured problem-solving activities. The Activity-Based E-SIM may be used as a supplementary resource for learners who require additional practice in applying the Law of Sines and Law of Cosines.

- For students, the intervention provides an alternative learning environment in which mathematical concepts can be revisited through guided activities, interactive exercises, practice tasks, and assessment activities. Such resources may be particularly useful for learners who benefit from opportunities to work through mathematical problems at an appropriate pace and revisit difficult concepts.
- For schools and school leaders, the findings suggest that investments in digital learning resources may be most productive when technology is integrated with clear instructional objectives and targeted remediation programs. The results do not support replacing conventional remediation with electronic materials solely because they are digital. Instead, schools may consider combining electronic and conventional resources according to learner needs, teacher capacity, available infrastructure, and the characteristics of the target competency.
- For learning-resource developers, the study emphasizes the importance of designing electronic intervention materials around specific learning difficulties rather than simply converting printed materials into digital formats. Activity sequences, guided practice, feedback, assessment, and reinforcement should be aligned with the cognitive demands of the competency being addressed.

Limitations of the Study - The findings should be interpreted in light of several limitations. First, the study involved only 40 Grade 9 students from a single public secondary school, limiting the generalizability of the findings to other schools, grade levels, and educational contexts. Second, the study used intact classes rather than individual random assignment; consequently, unmeasured differences between groups cannot be completely ruled out despite the absence of a significant pretest difference. Third, the intervention focused on a single Grade 9 mathematics competency involving the solution of oblique triangles, particularly the application of the Law of Sines and Law of Cosines. The findings therefore cannot be generalized to mathematics learning as a whole. Fourth, the same researcher-developed assessment was administered before and after the intervention. Although this permitted direct comparison of performance, exposure to the assessment during the pretest may have contributed to familiarity effects during the posttest. Fifth, the study focused on achievement in problem solving and did not directly measure variables such as motivation, engagement, metacognition, or retention of learning. Finally, the study examined performance immediately following the intervention and therefore did not establish whether the observed gains were sustained over time.

Future Research - Future research may replicate the study with larger samples drawn from multiple schools to improve the generalizability of the findings. Randomized or matched-group designs may also be considered where feasible to strengthen causal inference. Longer intervention periods and delayed posttests are recommended to determine whether learning gains are sustained over time. Future studies may also examine the effects of Activity-Based E-SIMs on related outcomes such as mathematical motivation, engagement, self-regulation, metacognitive awareness, and retention. Comparative investigations involving different forms of electronic and conventional intervention materials may further clarify which instructional features, rather than the digital medium itself, contribute most strongly to learning improvement. Finally, future research may examine the effectiveness of Activity-Based E-SIMs across other mathematics competencies and grade levels.

6. Conclusions

The study found that both the Activity-Based Electronic Strategic Intervention Material (E-SIM) and conventional paper-based remediation were associated with substantial improvement in Grade 9 students' problem-solving performance in solving oblique triangles. The two groups demonstrated comparable baseline performance, and both showed statistically significant pretest-to-posttest improvement. Although the Activity-Based E-SIM group obtained a higher posttest mean and a slightly greater mean gain than the conventional-remediation group, the between-group difference was not statistically significant. The gain-score comparison and ANCOVA both failed to demonstrate a statistically significant advantage of the Activity-Based E-SIM. Thus, the findings do not support the conclusion that the E-SIM was superior to conventional remediation under the conditions of the present study. The findings nevertheless demonstrate the potential of an Activity-Based E-SIM as a supplementary resource for competency-focused mathematics remediation. More broadly, the results suggest that the value of electronic intervention materials may depend less on their digital format alone than on the alignment of their activities, guided practice, assessment, and reinforcement with the specific learning difficulty being addressed. Larger, multi-school, and longer-term studies are needed to determine whether the potential advantages of activity-based electronic interventions become more evident across different mathematics competencies and learning contexts.

Declaration of AI and AI-Assisted Technology Use - During the preparation of this manuscript, I used ChatGPT (OpenAI, GPT-5.6 Luna; August 2026) for language editing, manuscript organization, academic writing refinement, and suggestions for improving selected sections. I reviewed, verified, and revised all AI-assisted outputs, including the manuscript text, statistical interpretations, citations, references, and methodological content. I independently validated the reported statistical results against the study data and take full responsibility for the originality, accuracy, integrity, and ethical compliance of the manuscript. No confidential or personally identifiable participant information was entered into the AI tool.

7. References

Adam, A.S., Mubarok, H. & Suprapto, N. Empowering all-in-one e-book package into guided inquiry learning: Analysis of students' learning achievement and critical thinking skill. *J Sci Educ Technol 35*, 369–383 (2026). https://doi.org/10.1007/s10956-025-10253-w

Aligo, B. L., & Prudente, M. S. (2025). Effectiveness of digital learning materials on students' achievement in science: A meta-analysis. *Journal of Global Education and Research, 9*(1), 55-69. https://www.doi.org/10.5038/2577-509X.9.1.1427

Bairy, S., Inamdar, N. Enhancing middle school mathematics through interdisciplinary integration: a 21st-century approach. *Discov Educ 5*, 22 (2026). https://doi.org/10.1007/s44217-025-00877-w

Cetin, N. I., Muslu-Komurcu, N., & Okulu, H. Z. (2026). Enhancing preservice science teachers' self-efficacy and technology integration tendency through Web 2.0-based instruction. *European Journal of Education, 61*(2), e70614. https://doi.org/10.1111/ejed.70614

Garcia, A. D. (2026). Improving students' knowledge on demonstrative pronouns through strategic intervention material. *Anatolian Journal of Education, 11*(1), 193-204. https://doi.org/10.29333/aje.2026.11113a

Glassmeyer David, Brakoniecki Aaron, M. Amador Julie, . (2019) Promoting uncertainty to support preservice teachers' reasoning about the tangent relationship. *International Journal of Mathematical Education in Science and Technology*

Hori, R., Fujii, M., Toguchi, T. et al. Impact of an efl digital application on learning, satisfaction, and persistence in elementary school children. *Early Childhood Educ J 53*, 1851–1862 (2025). https://doi.org/10.1007/s10643-024-01653-5

Ingebrigtsen, M., Å. O. Miland, J. Bastesen, and R. G. Sæle. 2025. Effective, scalable, and low cost: The use of teacher-made digital flashcards improves student learning. *Applied Cognitive Psychology 39*, no. 4: e70086. https://doi.org/10.1002/acp.70086

Kalay, A. & Arıkan, Y. D. (2023). The effects of gamified instructional material on learners' perceived motivation and academic achievement. *Journal of Educational Technology & Online Learning, 6*(3), 789-807.

Kayaalp, F., Meral, E., & Gökbulut, B. (2026). Is technology a sleeping giant in social studies? The influence of augmented reality on students' academic achievement, motivation, and attitudes. *International Journal of Human–Computer Interaction*. Advance online publication. https://doi.org/10.1080/10447318.2026.2670533

Kanber, H., Jassim, K., Al-Taai, S., Ibrahim, M., &Farhan, N. (2025). The role of digital educational content in eliminating traditional methods in the educational process within Iraqi universities. *Educational Process: International Journal, 14*, e2025050. https://doi.org/10.22521/edupij.2025.14.50

Lei, Q., Liu, D., Chen, X., Hirni, M., Wang, J., Abdelnaby, H. et al. (2025) Mathematics anxiety, trait emotional intelligence, and self-concept: Pathways to mathematics performance in students with and without mathematics learning difficulties. *Journal of Research in Special Educational Needs, 25*, 945–957. Available from: https://doi.org/10.1111/1471-3802.70020

Liu, Y., Rott, B., Toh, T.L. et al. Teachers' beliefs and their interplay with practice on mathematical problem solving within project-based learning: A case study. *Int J of Sci and Math Educ 24*, 31 (2026). https://doi.org/10.1007/s10763-026-10658-y

Manlapig, E. F., Jr., Acuña, E. B., & Manuel, A. M. (2024). Exploring student academic performance and motivation in physics through electronic-strategic intervention material (e-SIM). *Anatolian Journal of Education, 9*(1), 145–156. https://doi.org/10.29333/aje.2024.9110a

Natanael Karjanto, Mollweide's formula in teaching trigonometry, teaching mathematics and its applications. *An International Journal of the IMA, 30*, 2, June 2011, Pages 70–74, https://doi.org/10.1093/teamat/hrr008

Niki Aira P Francisco, Jason S Valera & Jenny A Galay-Limos. (2026) Teaching strategies, stem students' attitude and academic performance in Physics. *International Journal of Research Studies in Education 15*:10.

Rosal, G. M., Aguinaldo, J. C. M., Reyes, L. D. B., Casuat, G. H. U., Balagtas, R. U., & Del Mundo, E. F. (2022). Improving the least mastered competencies of Grade 11 students in General Chemistry using electronic strategic intervention material (E-SIM). *KIMIKA, 33*(2), 59–76. https://doi.org/10.26534/kimika.v32i2.59-76

Santos, M. A. D. (2026). Matheractive 5: Technology-enhanced learning (tel) in developing mathematical skills through real-life scenarios. *Journal of Educational Technology Systems, 54*(4), 843-854.

Sattabut, W. & Phusee-orn, S. (2026). The development of creativity by using 5e inquiry learning activities integrated with games on social studies, religion and culture subject of phrathomsuksa 4 students. *International Education Studies, 19*(1). https://doi.org/10.5539/ies.v19n1p28

Susanna, T., Lasse, E., Henrik, N.J. et al. From problem-solving to reflection: activating diverse metacognitive skills in mathematics. *Int J of Sci and Math Educ 24*, 10 (2026). https://doi.org/10.1007/s10763-025-10643-x

Toni Chehlarova, Ivan Petkov, Neda Chehlarova & Natalia Gecheva. (2025) Research on the development of the percentage visual estimation with computer models. *Педагогически форум 13*:4, pages 3.

Wang, J., Tigelaar, D. E. H., Ye, T., & Admiraal, W. (2026). A meta-analysis of moderators of the effects of technology-enhanced adaptive learning on primary and secondary students' learning outcomes. *Journal of Computer Assisted Learning, 42*(1), e70168. https://doi.org/10.1002/jcal.70168

Yuhui Jing, Runyi Hu & Rustam Shadiev. (2026) Pathways and optimization of generative AI in higher education teaching: a text mining and content analysis approach. *Interactive Learning Environments*, 1-27.

Yüksel, I. Impact of activity-based mathematics instruction on students with different prior knowledge and reading abilities. *Int J of Sci and Math Educ 12*, 1445–1468 (2014). https://doi.org/10.1007/s10763-013-9474-0

Zhidkikh, D., Saarela, M., & Kärkkäinen, T. (2023). Measuring self-regulated learning in a junior high school mathematics classroom: Combining aptitude and event measures in digital learning materials. *Journal of Computer Assisted Learning, 39*(6), 1834–1851. https://doi.org/10.1111/jcal.12842