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Teaching Trigonometry Using Khan Academy Application

Mary Joy A. Cartagena[1], Hermie V. Inoferio, PhD[2]
[1]*Jose Rizal Memorial State University - Main Campus, Dapitan City, Zamboanga del Norte, Philippines*
[2]*Jose Rizal Memorial State University - Katipunan Campus, Zamboanga del Norte, Philippines*

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Email of Corresponding Author: maryjoycartagena1997@gmail.com

Abstract

This study determined the effectiveness of the Khan Academy application as a primary instructional material in teaching Trigonometry, specifically the Law of Sines, Law of Cosines, and Oblique Triangles, among Grade 9 students at Aloran Trade High School during the School Year 2025–2026. Anchored on Bloom's Mastery Learning Model and supported by the concepts of immediate feedback and the Input-Process-Output (IPO) Model, the study utilized a quasi-experimental non-randomized control group pre-test–post-test research design. Two intact Grade 9 classes participated in the study, consisting of a Control Group taught through conventional lecture-discussion methods and an Experimental Group that utilized the Khan Academy application integrated with face-to-face instruction and mastery-based activities. A validated 30-item standardized assessment instrument with a KR-20 reliability coefficient of 0.817 was administered as both pre-test and post-test. Data were analyzed using Mean Percentage Score (MPS), paired samples t-test, independent samples t-test, and Cohen's d effect size. The findings revealed that both groups initially demonstrated Beginning-level proficiency in Trigonometry and showed significant improvement after instruction. However, the Experimental Group achieved significantly higher post-test performance and greater mean gain scores compared to the Control Group, indicating that the Khan Academy application enhanced students' mastery and proficiency more effectively than conventional instruction alone. Students identified instant feedback, mastery-based activities, and interactive visualization as beneficial features, although technical challenges such as unstable internet connectivity and limited mobile device functionality affected usability. The study concluded that blended learning integrating digital mastery tools and teacher support is an effective approach for improving mathematical understanding and academic performance. The study supports Sustainable Development Goal (SDG) 4 on Quality Education through the promotion of accessible and technology-enhanced learning. It also aligns with SDG 9 on Industry, Innovation and Infrastructure by encouraging the integration of digital platforms into classroom instruction. The findings contribute to educational sustainability by supporting technology-driven, learner-centered instruction and strengthening institutional practices for data-driven and adaptive learning environments.

Keywords: Blended Learning, Khan Academy Application, Mastery Learning, Mathematics Performance, Oblique Triangles, Trigonometry, Technology-Enhanced Learning, Traditional Instruction

1. Introduction

The shift from traditional classroom instruction to flexible and technology-integrated learning has transformed mathematics education. Blended learning, which combines face-to-face instruction with digital tools, enables students to learn at their own pace while teachers function as facilitators rather than sole lecturers (Garrison & Vaughan, 2008). In mathematics instruction, the Khan Academy application supports individualized learning through interactive exercises, instructional videos, and immediate feedback mechanisms that reinforce mastery learning. The need for innovative instructional approaches is particularly urgent in the Philippine educational context. The 2022 Programme for International Student Assessment (PISA) results revealed that the Philippines ranked among the lowest-performing countries in mathematics (DepEd National Report, 2023). These findings suggest that conventional teaching strategies may no longer adequately address the learning needs of contemporary students. Consequently, digital interventions such as the Khan Academy application have gained importance in promoting conceptual understanding, reducing mathematics anxiety, and strengthening problem-solving skills (Vidergor et al., 2020; Lee & Kim, 2021). This study investigates the effectiveness of the Khan Academy application as a primary instructional material in teaching Trigonometry among Grade 9 students at Aloran Trade High School during the School Year 2025–2026. Specifically, it examines its impact on students' academic performance in the Law of Sines, Law of Cosines, and Oblique Triangles using a quasi-experimental research design.

1.1 Background of the Use of Khan Academy Application in Grade 9 Trigonometry Instruction at Aloran Trade High School

The integration of digital learning platforms into classroom instruction reflects the growing transition toward blended learning environments. According to Garrison & Vaughan (2008), blended learning combines traditional instruction with digital tools to create more flexible and learner-centered educational experiences. In this framework, teachers guide

classroom discussions while digital platforms support individualized practice and self-paced learning. The Khan Academy application serves as an effective instructional material because it provides immediate feedback, interactive exercises, and instructional videos that enhance students' understanding of mathematical concepts. Unlike traditional textbook-based instruction, the application enables students to revisit lessons, receive hints, and master prerequisite concepts before progressing to more advanced topics. Its Teacher Dashboard also allows instructors to monitor student progress and provide targeted interventions. The importance of technology-enhanced instruction became more evident following the poor mathematics performance of Filipino learners in the 2022 PISA results (DepEd National Report, 2023). To address these challenges, the Department of Education formally partnered with Khan Academy on August 5, 2024, through the Digital Rise Program, which promotes the integration of high-quality digital instruction into the curriculum. This initiative also aligns with DepEd Order No. 13, s. 2015, which emphasizes data-driven and research-based educational interventions. Research has shown that digital learning interventions improve student motivation and reduce mathematics anxiety (Vidergor et al., 2020). In Trigonometry, the Khan Academy application helps students visualize abstract relationships and patterns, thereby improving conceptual understanding (Lee & Kim, 2021). These features are especially beneficial for Grade 9 learners who often struggle with trigonometric concepts. Aloran Trade High School participates in this modernization effort through the implementation of blended learning strategies. However, the effectiveness of the Khan Academy application within a local trade school context remains insufficiently explored, thereby necessitating empirical investigation.

1.2 Themes and Insights on Khan Academy Application and Mathematics Performance in Trigonometry

The literature highlights several themes regarding the effectiveness of digital learning platforms in mathematics education. The Programme for International Student Assessment (PISA) defines mathematical literacy as the ability to formulate, employ, and interpret mathematics in solving real-world problems (OECD, 2023). Schleicher (2024) emphasized the widening proficiency gap among students who fail to achieve functional mathematical literacy. Recent studies indicate that the Khan Academy application aligns with global educational standards. Haleem et al. (2022) identified digital practice as a strong predictor of success in PISA assessments, while Khan Academy (2024) emphasized the importance of non-routine problem solving and critical thinking within its instructional design. Mathematical self-efficacy also emerged as a significant factor influencing academic achievement. Tan et al. (2025) stated that students' confidence in solving mathematical problems strongly affects performance outcomes. Patil & Juanico (2024) found that students using the Khan Academy application improved proficiency from 37% to 84% because of simplified explanations and guided practice. The effectiveness of the application is strongly associated with the Mastery Learning model. Vlădescu (2023) explained that mastery learning requires students to demonstrate understanding of foundational concepts before advancing to more complex topics. Pacuruco-García et al. (2021) further argued that this approach transforms Trigonometry into a more engaging and autonomous learning experience. Instructional scaffolding also supports mathematical learning. Major and Francis (2020) noted that "bite-sized" video lessons reduce cognitive overload, while Santos & Santos (2021) reported that replaying instructional videos improves retention of abstract mathematical concepts. McKenney and Visscher (2024) added that instant feedback functions as a digital tutor that supports students within their Zone of Proximal Development. Studies further emphasized the value of visualization tools in Trigonometry instruction. Zengin, Furkan, and Kutluay (2017) observed that memorization techniques such as SOH-CAH-TOA are ineffective without visual representation. Akkoyunlu & Soylu (2020) found that interactive graphs improve conceptual understanding, while Juandi (2025) demonstrated that digital graphing tools increase student engagement by connecting trigonometric functions to real-world situations. Philippine studies similarly support the integration of digital learning. Chua & Reyes (2022) observed that Filipino students often lack access to quality instructional resources despite technological familiarity. Bacolod (2022) found that self-paced learning reduces achievement gaps caused by rote instruction. Barrot (2024) emphasized the suitability of offline-capable resources in areas with unstable internet access, while Cerrado & Errabo (2020) reported that visual cues and simplified language help learners overcome reading comprehension barriers. Patron (2021) and Delgado & Espina (2023) further confirmed that blended learning reduces mathematics anxiety and increases classroom participation.

1.3 Local, National, and Global Context of Digital Learning in Grade 9 Trigonometry Education

Globally, educational systems increasingly adopt digital learning platforms to improve mathematical literacy and student engagement. International assessments such as PISA continue to highlight the importance of critical thinking and problem-solving skills in mathematics (OECD, 2023). However, many students worldwide struggle to achieve the minimum level of mathematical proficiency (Schleicher, 2024). Nationally, the Philippines faces persistent challenges in mathematics achievement, as reflected in the 2022 PISA results (DepEd National Report, 2023). To address these concerns, the Department of Education launched initiatives such as the Digital Rise Program (DepEd, 2024), which promotes the use of free digital learning resources, including the Khan Academy application. Locally, trade schools and provincial institutions experience additional challenges related to limited instructional materials and inconsistent internet connectivity. Research by Barrot (2024) emphasized the importance of flexible and accessible digital learning tools in rural educational settings. At Aloran Trade High School, integrating the Khan Academy application into Trigonometry instruction represents an effort to modernize teaching practices and improve student achievement through technology-enhanced learning.

1.4 Theoretical and Conceptual Basis of Khan Academy Application in Teaching Trigonometry

This study is anchored on the Mastery Learning Model developed by Bloom (1968), which asserts that students can achieve high levels of academic performance when provided with adequate time, appropriate learning conditions, and individualized support. Unlike traditional instruction that progresses regardless of student comprehension, mastery learning requires learners to demonstrate proficiency before advancing to more complex topics. The framework is reinforced by the concept of Immediate Feedback, which Guskey (2021) identified as a critical element of effective mastery learning. Through the cycle of instruction, formative assessment, and corrective feedback, students are able to address misconceptions and improve understanding. The Khan Academy application operationalizes this process by providing instant hints, corrections, and instructional videos. Vlădescu (2023) further argued that digital mastery tools provide instructional scaffolding that supports diverse learners in large classrooms. In this study, the application enables personalized instruction by allowing students to progress at their own pace while teachers provide targeted interventions using data from the Teacher Dashboard. The study also utilizes the Input-Process-Output (IPO) Model as its conceptual framework. The input includes the pre-test scores of Grade 9 students from the control and experimental groups. The process involves the implementation of the Khan Academy application through mastery-based instruction and teacher-facilitated support. The output consists of post-test performance, student feedback, and improved mathematical proficiency in Trigonometry.

1.5 Research Gaps and Rationale on the Use of Khan Academy Application in Trade High School Mathematics Instruction

Although previous studies confirmed the effectiveness of digital learning platforms in improving mathematical performance, limited literature specifically examined the use of the Khan Academy application among Grade 9 students in Trade High School settings. Existing studies primarily focused on general mathematics achievement, digital literacy, and blended learning environments without concentrating on Trigonometry competencies such as the Law of Sines, Law of Cosines, and Oblique Triangles. Furthermore, there remains insufficient localized research investigating the effectiveness of the Khan Academy application within rural Philippine schools. This study addresses these gaps by evaluating the academic performance of Grade 9 students at Aloran Trade High School during the School Year 2025–2026 using a quasi-experimental design.

1.6 Alignment of the Study on Khan Academy Application with Relevant Sustainable Development Goals (SDGs)

This study aligns primarily with SDG 4 – Quality Education, which promotes inclusive and equitable quality education and lifelong learning opportunities for all. By integrating the Khan Academy application into mathematics instruction, the study supports innovative and accessible learning approaches that enhance student engagement and academic achievement. The research also relates to SDG 8 – Decent Work and Economic Growth, as improved mathematical proficiency contributes to the development of analytical and problem-solving skills necessary for future employment and workforce readiness. In addition, the study supports SDG 9 – Industry, Innovation and Infrastructure through the integration of digital technology into educational practices. The implementation of blended learning further contributes to SDG 10 – Reduced Inequalities by providing students in provincial and trade school settings with access to high-quality instructional resources comparable to those available in more urbanized educational institutions.

1.7 Importance of the Study on Khan Academy Application to Multidisciplinary Sustainability

This study contributes to educational sustainability by promoting technology-enhanced instruction that supports continuous and adaptive learning. The use of digital instructional materials encourages independent learning, critical thinking, and long-term academic development among students. The research also contributes to socio-economic sustainability by improving mathematical competencies that are essential for future career opportunities and workforce preparedness. Through blended learning, students develop digital literacy and problem-solving skills that are increasingly necessary in modern industries and technological environments. Additionally, the study supports technological and institutional sustainability by encouraging schools to adopt data-driven educational practices. The utilization of the Khan Academy Teacher Dashboard enables evidence-based instructional interventions, aligning with national educational modernization initiatives and strengthening institutional capacity for effective teaching and learning. Finally, the study contributes to community sustainability by addressing educational gaps in rural and trade school contexts, thereby supporting equitable access to quality education and improved academic outcomes for learners in underserved areas.

2. Material and methods

2.1 Research Design

This study utilized a Quasi-Experimental Research Design, specifically the Non-Randomized Control Group Pre-test–Post-test Design. The design was appropriate because the researcher used existing intact class sections rather than randomly assigning students to groups. The study aimed to determine the effectiveness of using Khan Academy as a primary instructional material on the Mathematics performance of Grade 9 students at Aloran Trade High School. The study involved two pre-existing Grade 9 classes under the researcher's teaching load. The groups were assumed to possess

comparable baseline mathematical skills, which were statistically verified through a pre-test developed by Mathematics Master Teachers and experts from the Division of Misamis Occidental. One section served as the Control Group and was taught using the conventional lecture-discussion and textbook-based approach. The other section served as the Experimental Group and utilized the Khan Academy application integrated with face-to-face instruction, guided practice, video tutorials, and mastery-based activities.

2.2 Locale of the Study

The study was conducted at Aloran Trade High School located in Labo, Aloran, Misamis Occidental. As a public secondary institution, the school serves learners with diverse academic backgrounds. The locale was selected because the school is currently implementing the Khan Academy application as a primary instructional material in Mathematics. This initiative aims to address challenges in mathematics proficiency and enhance student engagement through digital learning resources. The school also possesses the necessary facilities, including computer laboratories and internet access, which supported the implementation of mastery-based learning and the conduct of the study.

2.3 Respondents of the Study

The respondents of the study were Grade 9 students officially enrolled at Aloran Trade High School during the School Year 2025–2026. The participants consisted of two intact class sections under the researcher's teaching assignment. The Control Group consisted of thirty-two (32) students, while the Experimental Group consisted of thirty-four (34) students. The respondents included both male and female students who participated in the pre-test, intervention, and post-test phases of the study.

2.4 Sample and Sampling Procedure

The study employed purposive sampling in selecting the participants. Two intact Grade 9 sections from the researcher's teaching load were chosen as respondents of the study. To ensure unbiased assignment of treatment, the Fishbowl Technique was utilized. The names of the two sections were placed in a container, and the first section drawn was assigned as the Control Group using the traditional teaching approach. The remaining section was designated as the Experimental Group utilizing the Khan Academy application integrated into instruction.

2.5 Research Instrument

The primary research instrument was a standardized 30-item Learning Activity Sheet used as both the pre-test and post-test. The assessment tool was developed by Mathematics Master Teachers and subject experts from the Division of Misamis Occidental to ensure alignment with the Most Essential Learning Competencies in Trigonometry. To establish reliability and internal consistency, pilot testing was conducted among Grade 9 students who were not included in the actual study. The results were analyzed using the Kuder-Richardson Formula 20 (KR-20), yielding a reliability coefficient of 0.817, which exceeded the acceptable threshold of 0.70. This confirmed that the instrument was highly reliable and appropriate for the target respondents. Student performance was interpreted using the Mean Percentage Score (MPS) proficiency levels stipulated in DepEd Order No. 8, s. 2015. Scores were categorized according to descriptive ratings and proficiency levels ranging from Beginning to Advanced.

2.6 Data Gathering Procedure

The study commenced after securing formal approval from the School Principal and the Mathematics Department Head of Aloran Trade High School. Upon approval, the researcher administered the validated 30-item pre-test simultaneously to both the Control and Experimental Groups to determine their baseline performance in Trigonometry. Following the pre-test administration, a two-week intervention period was conducted. The Control Group received instruction using the conventional lecture-discussion approach, while the Experimental Group utilized the Khan Academy application as the primary instructional material integrated with face-to-face teaching and mastery-based activities. After the intervention period, the same standardized instrument was administered as a post-test to both groups to measure academic gains. The test papers were collected, scored according to approved DepEd procedures, and encoded for statistical analysis.

2.7 Data Analysis Techniques

The gathered data were analyzed using descriptive and inferential statistical tools. The Mean Percentage Score (MPS) was used to determine the average performance level of the students in Trigonometry during the pre-test and post-test. The results were interpreted based on the descriptive equivalents stipulated in DepEd Memorandum No. 160, s. 2012. The t-test for dependent samples or paired t-test was used to determine whether there was a significant difference between the pre-test and post-test scores within each group. This statistical tool determined whether the intervention significantly improved student performance. The t-test for independent samples was utilized to determine whether there was a significant difference between the post-test performances of the Control and Experimental Groups. This analysis established whether the Khan Academy application was more effective than the conventional teaching approach. All statistical analyses were conducted at a 0.05 level of significance, which served as the basis for accepting or rejecting the null hypotheses of the study.

2.8 Ethical Considerations

The study was conducted in accordance with ethical standards to protect the rights and welfare of the Grade 9 student participants and their guardians. The research protocol underwent formal review and approval by the Research Ethics Committee (REC) prior to implementation. A dual-layered consent process was employed. Parents or guardians received a full explanation regarding the nature, purpose, risks, and benefits of the study before providing written consent. Student assent was subsequently secured through a separate orientation using simplified and age-appropriate language. Students were informed that participation was voluntary and that they could withdraw from the study at any time without academic consequences. The researcher acknowledged possible minor psychological stressors such as test anxiety and academic pressure. To minimize these risks, the study maintained a low-stakes environment and clarified that the assessment results would not affect students' official grades. Confidentiality and anonymity were strictly maintained throughout the study. Numerical codes were assigned to respondents instead of recording student names, and only aggregated data were used during statistical analysis and reporting. To ensure fairness, the Control Group was also provided access to the Khan Academy instructional materials and mastery-based strategies after the completion of the two-week intervention period.

3. Results and Discussion

3.1 Academic Performance of the Control and Experimental Groups in Trigonometry

3.1.1 Pre-test Performance of the Control and Experimental Groups

The results revealed that both the Control Group and Experimental Group demonstrated low baseline proficiency in Trigonometry before the intervention. The Control Group obtained a mean score of 12.84 with a standard deviation of 1.97, while the Experimental Group obtained a mean score of 12.24 with a standard deviation of 2.15. Both groups fell under the "Failed" category, indicating that all participants did not reach the passing level prior to instruction. The uniformly low performance suggests that students initially lacked sufficient foundational understanding of Trigonometry concepts. Morales (2021) explained that Trigonometry is a difficult mathematical domain because it requires the simultaneous application of algebraic and geometric principles. The comparable mean scores of both groups also established a homogeneous baseline, which is necessary for experimental validity. Cruz (2021) emphasized that equivalent baseline proficiency allows post-intervention improvements to be attributed to the instructional method rather than pre-existing academic differences.

3.1.2 Difference Between the Pre-test Performances of the Control and Experimental Groups

The statistical analysis showed no significant difference between the pre-test performances of the Control and Experimental groups. The computed t-value was -1.198 with a p-value of 0.235, which exceeded the 0.05 level of significance. This result led to the acceptance of the null hypothesis, confirming that both groups had comparable levels of prior knowledge before the intervention. The absence of a significant difference indicated that the two groups started from an equal academic condition. Fraenkel et al. (2023) noted that non-significant pre-test differences minimize selection bias in quasi-experimental research. Similarly, Gay et al. (2023) emphasized that equivalent baseline performance strengthens the validity of attributing post-test gains to the intervention rather than to pre-existing student ability.

3.1.3 Post-test Performance of the Control and Experimental Groups

Following the intervention, both groups improved their Trigonometry performance and reached passing levels. The Control Group achieved a mean score of 23.09 with a standard deviation of 2.64, while the Experimental Group obtained a higher mean score of 24.32 with a standard deviation of 2.10. The higher mean and lower variability observed in the Experimental Group indicate more consistent academic improvement among students exposed to the Khan Academy application. Garcia (2023) stated that digital interventions often reduce achievement gaps by providing individualized learning support. Bautista & Maligalig (2024) further explained that mastery-based digital platforms benefit trade school learners by helping them visualize and understand abstract trigonometric concepts more effectively.

3.1.4 Difference Between the Post-test Performances of the Control and Experimental Groups

The post-test comparison revealed a significant difference between the performances of the two groups. The computed t-value was 2.099 with a p-value of 0.040, which was lower than the 0.05 level of significance. This result led to the rejection of the null hypothesis and confirmed that the Experimental Group performed significantly better than the Control Group. The significant improvement of the Experimental Group suggests that the Khan Academy application positively influenced student learning outcomes. Tan and Lopez (2022) explained that individualized feedback loops improve retention of complex mathematical concepts more effectively than lecture-based instruction alone. Chen et al. (2025) further argued that significant gains in digitally supported instruction validate blended learning as an effective strategy for reducing mathematics anxiety and improving academic achievement in secondary education.

3.2 Improvement in the Performance of the Control and Experimental Groups

3.2.1 Difference Between the Pre-test and Post-test Performances of the Control Group

The Control Group demonstrated significant improvement after exposure to the conventional teaching approach. The mean score increased from 12.84 during the pre-test to 23.09 during the post-test, resulting in a mean difference of 10.25. The computed t-value was -18.42 with a p-value of less than 0.001. The Cohen's d value of 4.40 indicated a profound effect size. The findings indicate that traditional teacher-led instruction remained effective in improving students' Trigonometry performance. Santos (2022) observed that structured classroom lectures can substantially improve mathematical understanding among learners with weak foundational knowledge. However, despite the significant improvement, the conventional approach appeared to produce lower gains compared to the technology-integrated strategy. Garcia (2023) suggested that traditional instruction provides essential foundations but may have limitations in sustaining higher mastery levels compared to digital learning approaches.

3.2.2 Difference Between the Pre-test and Post-test Performances of the Experimental Group

The Experimental Group also demonstrated highly significant improvement after the integration of the Khan Academy application. The mean score increased from 12.24 in the pre-test to 24.32 in the post-test, producing a mean difference of 12.08. The computed t-value was -23.41 with a p-value of less than 0.001. The Cohen's d value of 5.68 indicated a profound effect size. The substantial improvement suggests that the mastery-based and feedback-oriented features of the Khan Academy application significantly enhanced student learning. Haleem et al. (2022) emphasized that immediate feedback prevents the accumulation of misconceptions and strengthens conceptual understanding. Patil & Juanico (2024) further argued that mastery-based digital instruction effectively moves students from Beginning levels toward higher proficiency by simplifying abstract trigonometric concepts through interactive visualization. The findings demonstrate that technology-enhanced instruction produced greater academic gains than conventional teaching methods.

3.2.3 Comparison of Mean Gain Scores Between the Control and Experimental Groups

The comparison of mean gain scores revealed that the Experimental Group achieved greater improvement than the Control Group. The Experimental Group recorded a mean gain of 12.08, while the Control Group obtained a mean gain of 10.25. Both groups showed significant progress; however, the Experimental Group demonstrated a higher rate of academic growth during the intervention period. The greater improvement among students exposed to the Khan Academy application supports the effectiveness of mastery-based digital learning. Vlădescu (2023) explained that digital mastery learning enables students to develop competency in foundational concepts before progressing to more advanced topics. Haleem et al. (2022) also identified consistent digital practice as a major predictor of mathematical success because it promotes critical thinking and non-routine problem-solving skills. The results indicate that the Khan Academy application provided the scaffolding and immediate feedback necessary for stronger academic growth in Trigonometry.

3.3 Challenges and Suggestions in Using the Khan Academy Application

Students identified several challenges while using the Khan Academy application in learning Trigonometry. The most common difficulties involved technical and connectivity issues, particularly unstable internet access, slow loading times, and video buffering. Students using mobile phones also struggled with small text and mathematical symbols. Some learners experienced difficulty understanding accents used in instructional videos and expressed concern regarding the lack of immediate teacher support when encountering complex problems. Additionally, students perceived the Mastery Bar system as overly sensitive because minor errors or typographical mistakes negatively affected their mastery scores. These challenges indicate that while digital instruction improves learning outcomes, technological and instructional limitations may affect student engagement and usability. The findings suggest that infrastructure support and instructional adaptation remain important in maximizing the effectiveness of blended learning environments. The students' feedback also reflects the need for more contextualized instruction and responsive digital support systems in mathematics education. Students proposed several suggestions to improve the implementation of the Khan Academy application in the classroom. They recommended the inclusion of a real-time support feature, such as direct teacher assistance within the platform, to help students address difficulties immediately. Learners also suggested incorporating more real-life examples related to construction, sports, and practical applications of Trigonometry. Additional recommendations included a more forgiving mastery algorithm, shorter instructional videos, and closer alignment between the application's terminology and the mathematical language used by classroom teachers. These suggestions highlight the importance of adapting digital instructional tools to the specific learning context and needs of students. The recommendations imply that combining technological innovation with contextualized and learner-centered instructional practices may further improve students' understanding and engagement in mathematics learning.

4. Conclusion & Recommendations

The study found that Grade 9 students initially demonstrated a Beginning level of understanding of the Law of Sines, Law of Cosines, and Oblique Triangles. Both conventional instruction and the Khan Academy application significantly improved students' academic performance; however, the experimental group that utilized Khan Academy achieved higher levels of Mastery and Proficiency than the control group. The findings further indicate that the application's mastery-based learning model and instant feedback mechanism effectively enhanced students' understanding of trigonometric concepts

and minimized mathematical errors. Despite the effectiveness of digital learning tools, technical difficulties such as unstable internet connectivity and limited hardware access remained challenges, emphasizing that digital platforms function best as supplementary tools alongside active teacher guidance in a blended learning environment.

Mathematics teachers are encouraged to integrate the Khan Academy application into a blended learning approach to enhance the teaching of the Law of Sines and Law of Cosines. School administrators should improve digital infrastructure by ensuring reliable internet connectivity and adequate technological resources to address the challenges experienced by students. The Department of Education and curriculum planners may consider incorporating mastery-based digital platforms to improve students' proficiency and mastery in mathematics across different classroom settings. Students should consistently utilize interactive digital resources to strengthen their understanding through self-paced learning, while future researchers are encouraged to conduct related studies across longer periods and other mathematical topics to further examine the effectiveness of digital instructional interventions.

The study was limited to Grade 9 students of Aloran Trade High School during the 2025–2026 academic year and focused only on the topics of the Law of Sines, Law of Cosines, and Oblique Triangles. The implementation of the digital intervention was also affected by technical challenges, including unstable internet connectivity and hardware limitations such as small mobile screens, which may have influenced students' learning experiences and performance.

Compliance with ethical standards

The study was conducted in accordance with ethical standards to protect the rights and welfare of the Grade 9 student participants and their guardians. The research protocol underwent formal review and approval by the Research Ethics Committee (REC) prior to implementation. Participation in the study was voluntary, and students were informed that they could withdraw at any time without academic consequences. Confidentiality and anonymity were maintained through the use of numerical codes instead of student names, and only aggregated data were used in the analysis and reporting of results.

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