

Enhancing Students' Mathematics Achievement Through a Web-Based Trigonometry Module: A Quasi-Experimental Study.

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ABSTRACT:

This study examined the effectiveness of a Web-Based Module in enhancing the mathematics achievement of students enrolled in Plane Trigonometry at Bohol Island State University during the first semester of Academic Year 2020–2021. A quasi-experimental research design utilizing a pre-test–post-test control group approach, together with a descriptive survey, was employed. The participants consisted of 57 first-year Bachelor of Science in Electrical Technology students from two intact classes. Students in the experimental group learned through the Web-Based Module, whereas those in the control group received instruction using Online Blended Instruction. Mathematics achievement was measured using a researcher-developed 20-item achievement test that underwent expert validation and demonstrated excellent internal consistency ($KR-20 = 0.9219$). Descriptive statistics, including the mean and standard deviation, were computed to summarize students' performance, while one-way Analysis of Covariance (ANCOVA) was used to determine differences in post-test achievement after controlling for pre-test scores. The findings showed that both instructional approaches contributed to improved mathematics achievement. However, students who utilized the Web-Based Module achieved significantly higher post-test scores than those who experienced Online Blended Instruction, $F(1, 54) = 9.69$, $p = .003$. These results suggest that integrating the 4A's Instructional Model with web-based learning resources provides a more effective approach to improving mathematics achievement in an online learning environment. The study recommends incorporating web-based instructional modules into tertiary mathematics courses and conducting further investigations involving larger samples, diverse mathematical content, and different educational contexts.

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1. INTRODUCTION

Mathematics achievement plays a vital role in determining students' academic success and serves as an important indicator of educational attainment (Pandey, 2017). Despite ongoing initiatives to improve mathematics education, many learners continue to experience unsatisfactory performance. Higgins et al. (2019) observed that educational systems worldwide continue to search for more effective instructional approaches capable of improving students' achievement, motivation, and attitudes toward mathematics. This concern is likewise reflected in the Philippine context, where the results of the Trends in International Mathematics and Science Study (TIMSS) 2019 revealed that Filipino students performed among the lowest in mathematics compared with their international counterparts (Mullis et al., 2020).

Researchers have identified numerous factors that contribute to students' low mathematics achievement. According to Ganai and Guaiab (2014), ineffective classroom instruction remains one of the major barriers to students' mastery of mathematical competencies. Similarly, Chand et al. (2021) emphasized that inadequate integration of educational technology limits opportunities for meaningful learning and contributes to poor academic performance. These findings underscore the importance of designing and developing instructional materials that respond to learners' needs, interests, and varying levels of academic ability (Andaya, 2014).

Developing mathematical problem-solving competence is a fundamental objective of mathematics education because it encourages analytical reasoning and conceptual understanding (Verzosa & Vistro-Yu, 2019). Effective problem-solving activities require learners to engage in meaningful mathematical thinking that promotes higher-order cognitive skills (Novita et al., 2012). Nevertheless, many students continue to encounter difficulties in solving mathematical problems (Culaste, 2011), often because learning experiences fail to provide sufficient opportunities for conceptual understanding and authentic mathematical

reasoning (Xin, 2007).

Among the learner-centered approaches that have shown promise in mathematics education is experiential learning. Hulaikah et al. (2020) reported that experiential learning significantly strengthens students' problem-solving abilities by actively involving them in the learning process. One instructional approach that reflects this philosophy is the 4A's Instructional Model, which consists of Activity, Analysis, Abstraction, and Application and encourages learners to construct knowledge through meaningful experiences (Simbulan, 2018). Previous studies have demonstrated that this instructional model improves learners' motivation, confidence, and classroom participation (Carreon et al., 2019), while also promoting independent exploration of mathematical concepts (Leong & Alexander, 2014). Moreover, Wang et al. (2018) emphasized that innovative pedagogical approaches should be complemented by educational technologies to create more engaging and effective mathematics instruction. These findings suggest that integrating learner-centered pedagogy with technology has the potential to improve students' learning experiences and academic outcomes.

The increasing use of web-based instruction has transformed the delivery of educational content by providing learners with flexible, accessible, and technology-supported learning opportunities. Web-based learning environments enable students to access instructional materials anytime and anywhere, support individualized learning, facilitate regular updating of instructional resources, and accommodate a variety of innovative teaching strategies (Mathew & Dohery-Poirier, 2000; Rosenberg & Foshay, 2002). Despite these advantages, several challenges remain. Olson and Wisner (2002) pointed out that maintaining meaningful interaction and providing immediate instructional feedback continue to be major concerns in online learning environments. Likewise, Amuko (2015) argued that many technology-based learning systems prioritize technical features while giving insufficient attention to sound pedagogical principles and instructional design.

Although numerous investigations have independently established the effectiveness of web-based instruction and the 4A's Instructional Model in improving student learning, limited research has examined the combined application of these approaches in teaching Plane Trigonometry within Philippine higher education. In particular, little empirical evidence is available regarding the integration of the 4A's Instructional Model into a web-based learning environment designed for tertiary mathematics instruction. Addressing this gap is essential to determine whether the combination of learner-centered pedagogy and web-based technology can produce greater improvements in students' mathematics achievement than conventional online instructional approaches.

Guided by these considerations, the present study evaluated the effectiveness of a Web-Based Module incorporating the 4A's Instructional Model in teaching Plane Trigonometry to first-year Bachelor of Science in Electrical Technology students at Bohol Island State University. Specifically, the study compared the mathematics achievement of students who utilized the Web-Based Module with those who received Online Blended Instruction. The findings are expected to enrich the existing literature on technology-enhanced mathematics education and provide evidence that may assist mathematics educators, curriculum planners, and higher education institutions in designing more effective technology-supported instructional strategies.

The research design is illustrated as follows:

Group	Pre-test	Treatment	Post-test
Experimental Group	O ₁	T ₁ (Web-Based Module)	O ₂
Control Group	O ₁	T ₂ (Online Blended Instruction)	O ₂

Where:

- O₁ = Pre-test (Mathematics Achievement Test administered before the intervention)

2. METHODOLOGY

The research was carried out at Bohol Island State University (BISU)–Main Campus, Tagbilaran City, Bohol, Philippines, during the first semester of the 2020–2021 academic year. The participants were first-year students enrolled in the Bachelor of Science in Electrical Technology program who were taking the course Plane Trigonometry with Solid Mensuration.

A quasi-experimental approach utilizing a pre-test–post-test control group design was adopted to evaluate the effectiveness of the Web-Based Module in enhancing students' mathematics achievement. Two existing classes served as the study groups and were randomly designated as the experimental group and the control group. Prior to the implementation of the instructional interventions, both groups completed a pre-test to determine their initial level of mathematics achievement. Following the intervention period, the same achievement test was administered as a post-test to measure students' learning outcomes. Students assigned to the experimental group received instruction through the Web-Based Module, whereas those in the control group underwent Online Blended Instruction. For this investigation, the instructional approach constituted the independent variable, while students' mathematics achievement represented the dependent variable.

- T₁ = Instruction using the Web-Based Module
- T₂ = Instruction using Online Blended Instruction

- O₂ = Post-test (Mathematics Achievement Test administered after the intervention)

A total of fifty-seven (57) first-year Bachelor of Science in Electrical Technology students participated in the study. The respondents came from two intact classes, with twenty-seven (27) students in BS Electrical Technology 1-1 assigned to the experimental group and thirty (30) students in BS Electrical Technology 1-2 assigned to the control group. Students in the experimental group were instructed using the Web-Based Module, whereas those in the control group received Online Blended Instruction.

Students' mathematics achievement was assessed using a researcher-developed 20-item multiple-choice Mathematics Achievement Test

(MAT). Prior to its administration, the instrument underwent pilot testing, item analysis, and a test-retest procedure to evaluate its quality and reliability. Internal consistency was determined using the Kuder-Richardson Formula 20 (KR-20), which yielded a reliability coefficient of 0.9219. This coefficient indicates that the instrument possesses excellent reliability and is appropriate for measuring students' mathematics achievement.

The Mathematics Achievement Test comprised twenty multiple-choice questions, with one (1) point awarded for each correct answer. Students' scores were interpreted using the descriptive achievement levels established under the grading system of Bohol Island State University (BISU). The corresponding score ranges and descriptive equivalents are presented in the succeeding table.

Table 1. Descriptive Statistics and Interpretation of Mathematics Achievement Test Scores

Score	Rating	Descriptive Equivalent
19–20	90–100	Excellent
16–18	86–89	Proficient
11–15	80–85	Approaching Proficiency
6–10	75–79	Developing
1–5	Below 75	Beginning

Prior to the conduct of the study, permission was obtained from the appropriate university authorities. Both the experimental and control groups were administered the Mathematics Achievement Test as a pre-test to determine their initial level of mathematics achievement. The experimental group was then instructed using the Web-Based Module, whereas the control group received Online Blended Instruction covering the same learning competencies. Upon completion of the intervention, both groups were administered the same Mathematics Achievement Test as a post-test to determine the effectiveness of the

instructional methods.

The data collected were processed and analyzed using both descriptive and inferential statistics. The mean and standard deviation were used to describe students' mathematics achievement before and after the intervention. To determine whether a significant difference existed between the mathematics achievement of the experimental and control groups after controlling for pre-test scores, a one-way Analysis of Covariance (ANCOVA) was employed at the 0.05 level of significance.

3. RESULTS AND DISCUSSION

Table 2. Mean and Standard Deviation of Students' Mathematics Achievement

	Control Group n=30		Experimental Group N=27	
	Pre-test	Post-test	Pre-test	Post-test
Mean	4.60	10.23	5.19	13.67
SD	3.60	4.39	2.80	3.59
Qualitative Description (Mean)	Beginning	Developing	Beginning	Approaching Proficiency

Table 2 summarizes the pre-test and post-test performance of the experimental and control groups on the Mathematics Achievement Test using the mean and standard deviation. Prior to the implementation of the instructional interventions, the control group obtained a mean score of 4.60 (SD = 3.60), whereas the experimental group attained a mean score of 5.19 (SD = 2.80). The small difference between the two pre-test means suggests that the participants had comparable levels of mathematics achievement at the beginning of the study. Based on the established descriptive equivalents, the pre-test performance of both groups was classified under the Beginning level.

An increase in mathematics achievement was observed in both groups after the instructional period. Students who received Online Blended

Instruction obtained a mean post-test score of 10.23, which corresponds to the Developing level. In contrast, students who utilized the Web-Based Module achieved a higher mean score of 13.67, placing them at the Approaching Proficiency level. The higher post-test mean obtained by the experimental group indicates greater learning gains than those achieved by the control group. Although these descriptive statistics suggest that the Web-Based Module yielded more favorable learning outcomes, inferential analysis was necessary to determine whether the observed difference between the two instructional approaches was statistically significant. Consequently, a one-way Analysis of Covariance (ANCOVA) was conducted to evaluate the effect of the instructional intervention after adjusting for differences in the students' pre-test scores.

Table 3. Results of One-Way ANCOVA on the Pre-Test and Post-Test Scores of the Mathematics Achievement Test

Source	Sum of Squares	Df	Mean Square	F	P-value
Treatment (Teaching Methods)	158.92	1	158.92	9.69	0.003*
Error within	885.79	54	16.40		
Total	1044.71	55			

*significant at 0.05

Table 3 presents the results of the one-way Analysis of Covariance (ANCOVA) conducted to determine whether a significant difference existed between the mathematics achievement of students who utilized the Web-Based Module and those who underwent Online Blended

Instruction. After adjusting for the influence of students' pre-test scores, the analysis showed a significant difference in post-test performance between the two groups, $F(1, 54) = 9.69$, $p = .003$. The obtained probability value was lower than the 0.05 level of significance; therefore, the null

hypothesis was rejected.

The result suggests that the instructional approaches produced different effects on students' mathematics achievement. Specifically, learners exposed to the Web-Based Module obtained significantly higher post-test scores compared with those who participated in Online Blended Instruction. This implies that the Web-Based Module provided a more effective learning approach in enhancing students' mathematical performance.

The higher achievement of students in the experimental group can be associated with the integration of the 4A's Instructional Model into the design of the Web-Based Module. The module was structured to engage learners in meaningful activities involving active learning, analysis of mathematical ideas, development of abstract understanding, and practical application of acquired knowledge. In addition, the web-based platform allowed learners to manage their learning pace, access instructional resources conveniently, and receive timely feedback, which contributed to deeper understanding and sustained involvement in mathematics learning.

The outcome of this study supports previous research highlighting the effectiveness of interactive and technology-supported instructional strategies. Barol (2005) emphasized that the 4A's Instructional Model facilitates meaningful learning by encouraging exploration and learner independence. Similarly, Leong and Alexander (2014) reported that web-based learning environments contribute to improved mathematics achievement through interactive features, prompt feedback, and increased learner participation. The findings also align with the conclusions of Tareef (2014), Hsu (2003), Marquez (2017), and Lashley (2017), who demonstrated that technology-assisted instructional approaches positively influence students' academic outcomes, particularly in mathematics.

4 CONCLUSION AND RECOMMENDATIONS

The results of the study affirm the effectiveness of the Web-Based Module as an instructional tool

for enhancing students' achievement in Plane Trigonometry. While both groups demonstrated improvement after receiving their respective instructional treatments, the students who utilized the Web-Based Module obtained significantly better post-test results compared with those who participated in Online Blended Instruction. This suggests that the integration of the 4A's Instructional Model within a web-based learning environment creates a more interactive and meaningful learning experience that supports students' mathematical understanding, active involvement, and overall academic performance.

Moreover, the findings emphasize the value of web-based instructional resources as supplementary materials for mathematics education in higher learning institutions, especially in contexts where online and blended modalities are utilized. The combination of technology-supported learning and learner-centered instructional practices provides students with flexible opportunities to engage with mathematical concepts, strengthen their understanding, and improve their learning outcomes.

In view of these findings, mathematics instructors may consider incorporating Web-Based Modules as additional learning resources to complement traditional teaching approaches and enhance students' achievement in mathematics. Future studies may further examine the effectiveness of similar technology-enhanced interventions across various mathematics subjects, academic levels, and learning environments using broader participant groups. Such investigations may provide deeper insights into the role of digital instructional materials and innovative pedagogical strategies in advancing mathematics teaching and learning.

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REFERENCES

- Amuko, S. (2015). Pedagogical practices in integration of ICT in teaching and learning mathematics in secondary schools in Nairobi County, Kenya. *IOSR Journal of Mathematics (IOSR-JM)*, 11(5), 20–23.
- Andaya, O. J. F. (2014). Factors that affect mathematics achievements of students of Philippine Normal University–Isabela Campus. *Researchers World: International Refereed Social Sciences Journal*, 5(4), 83–91.
- Barol, J. M. (2005). *The effectiveness of 4A's strategy on triangle congruence*. Trailblazer, 2. [Trailblazer, Volume 2](#)
- Carreon, J. R., Baltazar, M. A., De Leon, V. P., Peñaredonda, M. R., & Santos, R. F. (2019, April). *The use of 4A model instructional strategy to improve the reading skills of Grade 7 students*. <https://doi.org/10.13140/RG.2.2.17674.11207>
- Chand, S., Chaudhary, K., Prasad, A., & Chand, V. (2021). Perceived causes of students' poor performance in mathematics: A case study at Ba and Tavua secondary schools. *Frontiers in Applied Mathematics and Statistics*, 7, Article 614408. <https://doi.org/10.3389/fams.2021.614408>
- Culaste, I. C. (2011). Cognitive skills of mathematical problem solving of Grade 6 children. *International Journal of Innovative Interdisciplinary Research*, 1(1), 120–125.
- Ganal, N. N., & Guiab, M. R. (2014). Problems and difficulties encountered by students towards mastering learning competencies in mathematics. *Researchers World: International Refereed Social Sciences Journal*, 5(4), 25–37.
- Higgins, K., Huscroft-D'Angelo, J., & Crawford, L. (2019). Effects of technology in mathematics on achievement, motivation, and attitude: A meta-analysis. *Journal of Educational Computing Research*, 57(2), 283–319. <https://doi.org/10.1177/0735633117748416>
- Hsu, Y. C. (2003). *The effectiveness of computer-assisted instruction in statistics education: A meta-analysis* (Doctoral dissertation, The University of Arizona). ProQuest Dissertations & Theses. (UMI No. 3089963)
- Hulaikah, M., Degeng, I. N. S., & Murwani, F. D. (2020). The effect of experiential learning and adversity quotient on problem-solving ability. *International Journal of Instruction*, 13(1), 869–884. <https://doi.org/10.29333/iji.2020.13156a>
- Lashley, L. (2017). *The effects of computer-aided instruction in mathematics on the performance of Grade 4 pupils*. *SAGE Open*, 7(3), 2158244017712775. <https://doi.org/10.1177/2158244017712775>
- Leong, K. E., & Alexander, N. (2014). *College students' attitude and mathematics achievement using web-based homework*. *Eurasia Journal of Mathematics, Science and Technology Education*, 10(6), 609–615. <https://doi.org/10.12973/eurasia.2014.1220a>
- Marquez, L. V. (2017). *Development of computer assisted instruction (CAI) in college statistics*. *The Normal Lights*, 11(2), 180–207. <https://doi.org/10.56278/tnl.v11i2.534>
- Mathew, N., & Dohery-Poirier, M. (2000). Using the World Wide Web to enhance classroom instruction. *First*

Monday, 5(3). <https://doi.org/10.5210/fm.v5i3.732>

- Mullis, I. V. S., Martin, M. O., Foy, P., Kelly, D. L., & Fishbein, B. (2020). *TIMSS 2019 international results in mathematics and science*. TIMSS & PIRLS International Study Center, Boston College. <https://timssandpirls.bc.edu/timss2019/international-results/>
- Novita, R., Zulkardi, & Hartono, Y. (2012). Exploring primary student's problem-solving ability by doing tasks like PISA's question. *Journal on Mathematics Education*, 3(2), 133–150. <https://doi.org/10.22342/jme.3.2.571.133-150>
- Olson, T., & Wisher, R. A. (2002). The effectiveness of web-based instruction: An initial inquiry. *The International Review of Research in Open and Distributed Learning*, 3(2), 1–17. <https://doi.org/10.19173/irrodl.v3i2.103>
- Pandey, B. D. (2017). A study of mathematical achievement of secondary school students. *International Journal of Advanced Research*, 5(12), 1951–1954. <https://doi.org/10.21474/IJAR01/6165>
- Rosenberg, M. J., & Foshay, R. (2002). *E-learning: Strategies for delivering knowledge in the digital age*. *Performance Improvement*, 41(5), 50–51. <https://doi.org/10.1002/pfi.4140410512>
- Simbulan, S. G. (2018, July 21). *Aces of 4A's*. *SunStar Pampanga*. <https://www.pressreader.com/philippines/sunstar-pampanga/20180721/281612421186244>
- Tareef, A. B. (2014). *The effects of computer-assisted learning on the achievement and problem solving skills of the educational statistics students*. *European Scientific Journal*, 10(28), 271–289.
- Verzosa, D. M. B., & Vistro-Yu, C. P. (2019). Prospects and challenges in implementing a new mathematics curriculum in the Philippines. In C. P. Vistro-Yu & T. L. Toh (Eds.), *School mathematics curricula: Asian perspectives and glimpses of reform* (pp. 207–226). Springer. https://doi.org/10.1007/978-981-13-6312-2_11
- Wang, Z., Utemov, V. V., Krivonozhkina, E. G., Liu, G., & Galushkin, A. A. (2018). Pedagogical readiness of mathematics teachers to implement innovative forms of educational activities. *EURASIA Journal of Mathematics, Science and Technology Education*, 14(1), 25–35. <https://doi.org/10.12973/ejmste/79305>
- Xin, Y. P. (2007). Word problem solving tasks in textbooks and their relation to student performance. *The Journal of Educational Research*, 100(6), 347–360. <https://doi.org/10.3200/JOER.100.6.347-360>