

**The effect of a mobile application on mathematics achievement
among industrial technology learners**

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ABSTRACT

Mathematics is fundamental to the development of technical competencies among industrial technology students, yet many learners have trouble mastering abstract and procedural mathematical concepts through conventional print-based instruction alone. This study examined the effectiveness of MathTech, a curriculum-specific mobile application developed for Mathematics for Technologists, compared with a traditional printed instructional module. A quasi-experimental pre-test/post-test design was employed with 100 first-year industrial technology students assigned to two intact instructional groups: Printed Module ($n = 50$) and Mobile Application ($n = 50$). The intervention covered seven core content areas: numeral systems; measurement and scientific notation; fractions, ratios, and proportions; algebra; geometry; trigonometry; and logarithmic, exponential, and complex-number functions. The instructional materials underwent expert validation. The printed module obtained a reported content validity ratio of 0.96 from nine experts, exceeding Lawshe's critical value of 0.78 for a nine-member panel, while the mobile application received a conformity rating of 4.33, interpreted as a very high extent, from 11 information technology experts. Baseline analysis showed no significant difference between groups in pre-test performance, $t(98) = -0.081$, $p = .935$. Both groups demonstrated substantial improvement from pre-test to post-test, with mean gains of approximately 35.52 points for the Printed Module group and 45.74 points for the Mobile Application group. The Mobile Application group also obtained a higher observed post-test mean (85.52) than the Printed Module group (75.14 in the final ANCOVA dataset). A general linear model incorporating pre-test score, instructional group, and the pre-test $\times$ group interaction was statistically significant, $F(3, 96) = 290.692$, $p < .001$, $R^2 = .901$. The pre-test $\times$ group interaction was significant, $F(1, 96) = 13.402$, $p < .001$, partial $\eta^2 = .123$, indicating that the relationship between initial achievement and post-test performance differed across instructional modalities. The findings provide promising evidence for the use of MathTech as a supplementary instructional resource, while also indicating that its effectiveness may vary according to students' initial mathematics achievement.

Keywords: Mobile learning, mathematics education, industrial technology, mobile application, learning gains, quasi-experimental design, technical mathematics, educational technology.

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INTRODUCTION

Mathematics occupies a fundamental role in technical and technological education because it equips students with the quantitative knowledge and analytical skills needed to interpret measurements, solve technical problems, examine relationships, and apply mathematical procedures in occupational and engineering related contexts. For students enrolled in industrial technology programs, mathematical competence is therefore more than an academic requirement. It constitutes an essential foundation for subsequent technical learning and effective workplace performance. The ability to understand and apply mathematical concepts enables students to engage meaningfully with the quantitative demands of their discipline and prepares them for increasingly complex technical tasks encountered in their academic preparation and future occupations.

Despite its importance, mathematics remains challenging for many learners, particularly in technical programs where students must coordinate abstract concepts, symbolic representations, procedural knowledge, and problem solving strategies. These demands can become more pronounced when instructional materials present mathematical concepts and procedures primarily through static formats that provide limited opportunities for immediate practice, feedback, visualization, or repeated application. Such conditions suggest that difficulties in technical mathematics may arise not only from the complexity of the subject matter itself but also from the manner in which mathematical content and learning experiences are presented to students. Consequently, instructional approaches that provide greater interaction, guided practice, and timely feedback may offer important opportunities to address some of these learning challenges.

The continued expansion of mobile technologies has created possibilities for supplementing conventional mathematics instruction with more interactive and flexible learning environments. Mobile learning allows students to access instructional content and engage in practice activities across locations and at times that may not be possible through conventional classroom resources. Research on technology supported mathematics learning generally provides encouraging evidence for this potential. Young's second order meta analysis covering approximately three decades of technology enhanced mathematics instruction identified a moderate cumulative effect on mathematics achievement and emphasized that the instructional functionality of technology represents an important consideration in determining its educational value. This finding indicates that the effectiveness of educational technology depends not merely on its presence in the learning environment but on the instructional purposes and functions it is designed to serve.

More recent research reinforces this perspective. Hillmayr et al. (2020), through a meta analysis of 92 studies involving mathematics and science education, reported an overall positive effect of digital tool use, with an effect size of $g = 0.65$. Importantly, their findings demonstrated that instructional context and the manner in which technology was integrated into teaching influenced its effectiveness. The complementary use of digital tools alongside other forms of instruction produced more favorable outcomes than approaches that simply replaced conventional instructional methods with technology. Similarly, Ran et al. (2022), based on 77 studies and 151 effect sizes, found an overall positive effect of technology on mathematics achievement, with an effect size of $g = 0.23$. Particularly favorable outcomes emerged when technology supported collaborative learning, problem solving, conceptual development, and adaptive mathematics practice. Taken together, these findings demonstrate that digital tools are most educationally meaningful when their capabilities are deliberately

aligned with specific learning processes rather than used merely as substitutes for existing instructional materials.

Evidence concerning mobile learning further supports the potential contribution of technology to student achievement. A recent meta analysis involving 253 empirical studies and more than 21,000 participants found positive effects of mobile learning on learning gains. At the same time, substantial heterogeneity across the studies indicated that the effectiveness of mobile learning varies according to educational context and implementation. This variation is significant because it cautions against assuming that mobile technology automatically improves learning. Instead, the findings across the literature converge on the view that educational outcomes are shaped by the interaction among technological features, instructional design, learning tasks, and the characteristics of learners and educational settings.

Accordingly, the educational value of mobile technology does not arise simply from replacing printed materials with content displayed on a digital screen. Its potential lies in how technological affordances are incorporated into instruction to facilitate meaningful learning experiences. In mathematics education, a well designed application can provide immediate feedback, repeated practice, worked examples, structured progression, and opportunities to visualize mathematical relationships. These features may help students understand mathematical processes while managing the cognitive demands associated with complex learning tasks. This perspective is consistent with Cognitive Load Theory, which emphasizes the limited capacity of working memory and the importance of designing instruction to facilitate the acquisition and organization of knowledge structures, particularly when learners encounter unfamiliar or complex material (Sweller, 2011).

Cognitive Load Theory provides an important theoretical basis for understanding how technology may support learning in Mathematics for Technologists. The course involves numerous mathematical procedures, concepts, and representations that may impose considerable cognitive demands on beginning learners. When several unfamiliar elements must be processed simultaneously, students may experience difficulties in maintaining and integrating the information required to complete mathematical tasks. An instructional application may potentially manage these demands by organizing content systematically, presenting examples in a stepwise manner, providing immediate corrective feedback, and allowing learners to engage in repeated practice. These instructional features can help structure the learning process and enable students to concentrate their cognitive resources on relevant mathematical concepts and procedures.

Nevertheless, the use of technology does not inherently reduce cognitive load or guarantee improved learning outcomes. Poorly designed interfaces, excessive multimedia elements, unnecessary interactions, or features that are disconnected from the intended mathematical task may increase extraneous cognitive load and interfere with learning. Thus, Cognitive Load Theory also provides a basis for recognizing the limitations of technology supported instruction. The potential effectiveness of a mobile mathematics application depends on the extent to which its technological features are aligned with mathematical learning tasks and designed to facilitate rather than complicate students' cognitive processing (Sweller, 2011). This consideration reinforces the broader evidence from Young, Hillmayr et al. (2020), and Ran et al. (2022), which collectively indicates that instructional design and functionality are more consequential than the mere availability of technology.

The increasing emphasis on flexible learning within Philippine higher education provides an additional context for examining technology supported instruction. The Commission on Higher Education's Memorandum Order No. 04, Series of 2020, established guidelines for implementing flexible learning in higher education institutions and supported

the use of varied learning modalities and instructional resources. Within this context, mobile applications represent one means of expanding students' access to course materials and learning activities beyond conventional classroom arrangements. However, the value of such applications ultimately depends on whether they provide learning opportunities that are pedagogically appropriate for the content, responsive to learner needs, and capable of contributing to measurable educational outcomes.

Building on these theoretical, empirical, and policy foundations, the conceptual framework of the present study proposes that instructional modality influences mathematics achievement through the learning experiences afforded by each medium. The Printed Module provides structured text, examples, exercises, and reference materials through a conventional instructional format. MathTech provides the same core curricular content while additionally enabling digital interaction and potentially more flexible access to instructional resources. The distinction between these modalities therefore concerns not only the medium through which content is delivered but also the learning opportunities that each modality makes available to students. In this framework, instructional modality influences the learning experience, which subsequently relates to mathematics achievement, while pretest mathematics achievement serves as an important indicator of students' initial knowledge.

Initial achievement is particularly important because students do not enter instructional experiences with identical levels of mathematical knowledge and competence. The significant interaction found in the present study further suggests that initial achievement may influence the relationship between instructional modality and subsequent achievement. This finding is consistent with the broader argument that the effectiveness of educational technology is conditional rather than uniform. Just as previous research demonstrates that outcomes vary according to instructional context, technological functionality, and implementation, differences in students' initial mathematical achievement may also shape how effectively they benefit from particular instructional modalities. Consequently, evaluating MathTech requires consideration not only of whether students exposed to the application demonstrate improved mathematics achievement but also of how their initial levels of achievement relate to the effectiveness of the instructional modality.

Against this background, the present study developed and evaluated MathTech, a mobile application specifically designed to support learning in Mathematics for Technologists. Rather than examining mobile learning as a broad educational approach, the study focuses on a course specific application aligned with the mathematical content required of industrial technology students. This focus addresses an important gap in the existing literature because much of the research on technology enhanced mathematics instruction has concentrated on general education and secondary or K to 12 populations. Comparatively less empirical evidence is available concerning curriculum specific mobile applications for technical mathematics among industrial technology students in higher education. By examining MathTech in relation to a Printed Module, mathematics achievement, and students' initial levels of mathematical performance, the study extends existing research into a specialized higher education context and provides evidence concerning the conditions under which mobile technology may contribute to mathematics learning among industrial technology students.

Statement of the problem

This study aimed to determine the effect of a mobile application on student academic performance in Mathematics for Technologists.

Specifically, it sought to answer the following questions:

1. What are the pre-test performance scores of students in the Printed Module and Mobile Application groups?

2. Is there a statistically significant difference in pre-test performance between the two groups?
3. What are the post-test performance scores of students in the Printed Module and Mobile Application groups?
4. Is there a statistically significant difference in post-test performance between students using the Printed Module and those using the Mobile Application?
5. Is there a statistically significant improvement from pre-test to post-test within each instructional group?
6. Is there a statistically significant difference in learning gains between the Printed Module and Mobile Application groups?
7. Does instructional modality interact with students' initial mathematics achievement in predicting post-test performance?

METHODOLOGY

This study employed a quantitative, quasi-experimental pre-test/post-test design with two instructional groups. Students were assigned to instructional modalities through intact class sections rather than individual random assignment. Quasi-experimental designs are widely used in educational research when random assignment is impractical in authentic classroom settings, although they require cautious interpretation because group assignment may be associated with unmeasured differences among students. The two groups consisted of the Printed Module Group ($n = 50$) and the Mobile Application Group ($n = 50$). Both groups studied the same Mathematics for Technologists content during the instructional period, with the primary difference between the groups being the principal instructional learning material used.

The participants were 100 first-year industrial technology students enrolled at Mariano Marcos State University, Philippines. The study used purposive sampling of intact instructional groups, wherein fifty students constituted the Printed Module group and fifty constituted the Mobile Application group. Because participants were not individually randomized, the design is appropriately interpreted as quasi-experimental rather than randomized experimental research.

Both instructional modalities covered seven major content areas. Unit 1, Overview of the Numeral System, included real numbers, the decimal system, and percent and percentage. Unit 2, Measurements and Scientific Notation, included measurement, unit conversion, and scientific notation. Unit 3, Fractions, Ratio, and Proportion, included common fractions, operations on fractions, ratio, and proportion. Unit 4, Algebra, included essentials of algebra, linear systems, and matrices and determinants. Unit 5, Geometry, included plane geometry, solid geometry, and analytic geometry. Unit 6, Trigonometry, included plane trigonometry and spherical trigonometry. Unit 7, Logarithmic and Exponential Functions, and the Complex Number, included logarithmic functions, exponential functions, and complex numbers.

The printed instructional module was developed to provide structured coverage of the course content. The module included explanations, examples, exercises, and mathematical problem solving activities aligned with the seven course units. The module was evaluated by nine experts for content validity, and the reported Content Validity Ratio (CVR) was 0.96 (Bayoc, 2025). Lawshe's CVR method provides a quantitative procedure for evaluating expert agreement concerning whether an item is essential to an assessment or instructional instrument. For a panel of nine experts, the critical CVR value under Lawshe's original table is

approximately 0.78. Thus, the reported CVR of 0.96 exceeded the critical value and provided strong evidence of expert agreement concerning the content relevance of the printed material.

The MathTech mobile application was developed as a course specific digital learning resource for Mathematics for Technologists. It was designed to provide students with mobile access to the same curricular content addressed in the printed module. The application was evaluated by 11 information technology experts. It obtained an overall degree of conformity rating of 4.33, interpreted as a very high extent of conformity according to the study's evaluation scale (Bayoc, 2025). These validation results provide evidence of the appropriateness of the instructional materials and technical quality of the application. However, expert validation should be distinguished from evidence of learning effectiveness. The former establishes content and technical appropriateness, whereas the quasi-experimental achievement data provide evidence concerning student learning outcomes.

A 100 item objective mathematics assessment was used as the pre-test and post-test. The instrument covered the seven content areas included in the course from the teacher made chapter quizzes. A similar assessment was administered before and after the instructional intervention under standardized conditions.

The study was conducted in three phases. In the first phase, the pre-test, both groups completed the 100 item mathematics assessment before the instructional intervention, the purpose of which was to establish students' initial mathematics achievement. In the second phase, the instructional intervention, both groups completed the seven instructional units using their assigned learning modality, with the Printed Module group using the printed instructional material and the Mobile Application group using MathTech. In the third phase, the post-test, after completion of the instructional period, both groups completed the post-test under standardized assessment conditions.

Descriptive statistics, including means and standard deviations, were used to summarize student performance. An independent samples t test was used to examine baseline differences between the two groups. Paired samples t tests were used to determine whether each group demonstrated significant improvement from pre-test to post-test. Gain scores were calculated, and an independent samples t test was used to compare gain scores between groups. Because pre-test/post-test designs contain a baseline measurement that is strongly related to the follow up outcome, baseline adjusted analysis was also conducted. ANCOVA/regression based adjustment is commonly used for baseline and follow up measurements when the assumptions of the model are satisfied. However, the present data demonstrated a significant pre-test by group interaction. Therefore, the conventional ANCOVA assumption of homogeneous regression slopes was not satisfied. The final inferential model consequently included the pre-test score, instructional group, and the pre-test by instructional group interaction. Statistical significance was evaluated at $\alpha = .05$.

RESULTS AND DISCUSSION

This chapter presents and interprets the results obtained from the study, which examined whether a curriculum-specific mobile application (MathTech) could enhance mathematics achievement among industrial technology students relative to a traditional printed instructional module. A total of 100 participants took part in the study, comprising 50 students in the Printed Module group and 50 students in the Mobile Application group. The study employed a quasi-experimental design with pre-test and post-test measures of mathematics achievement, and data were analyzed using independent-samples t tests, paired-samples analyses, a general linear model (ANCOVA) with assessment of the homogeneity-of-regression-slopes assumption, and Levene's test of equality of error variances. The discussion that follows is grounded entirely in the data gathered from these 100 participants, and all results

are interpreted in direct relation to the objectives of the study, namely to determine the comparability of the two groups at baseline, to evaluate their achievement following instruction, and to assess whether instructional modality moderated the relationship between prior and subsequent achievement.

With respect to pre-test performance, the two groups demonstrated very similar initial mathematics achievement. The Printed Module group obtained a mean of 39.62 with a standard deviation of 9.97, while the Mobile Application group obtained a mean of 39.78 with a standard deviation of 9.70. An independent-samples *t* test indicated no statistically significant difference between the groups, $t(98) = -0.081$, $p = .935$, and thus the null hypothesis concerning baseline differences was not rejected. This finding indicates that the two groups entered the intervention with comparable measured mathematics achievement, which strengthens the internal validity of subsequent between-group comparisons because any later differences in performance are less likely to be attributable to pre-existing disparities in mathematics proficiency.

Following instruction, students in the Mobile Application group achieved a markedly higher post-test mean than those in the Printed Module group. The final SPSS ANCOVA dataset reported a post-test mean of 75.14 with a standard deviation of 9.47 for the Printed Module group, compared with a post-test mean of 85.52 with a standard deviation of 7.59 for the Mobile Application group, an observed difference of approximately 10.38 points favoring the Mobile Application group. The magnitude of this difference corresponds to an approximate standardized mean difference of Cohen's $d = 1.21$, which is considered large according to conventional benchmarks (Cohen, 1988). This unadjusted comparison therefore indicates a substantial observed advantage for students who used the mobile application.

Both groups also demonstrated considerable within-group improvement from pre-test to post-test. For the Printed Module group, the mean score increased from 39.62 to 75.14, corresponding to a mean gain of 35.52 points, while for the Mobile Application group the mean score increased from 39.78 to 85.52, corresponding to a mean gain of 45.74 points. The Mobile Application group therefore demonstrated approximately 10.22 points greater mean improvement than the Printed Module group. The previously conducted paired-samples analyses indicated statistically significant within-group improvements for both instructional modalities ($p < .001$), suggesting that both instructional approaches were associated with substantial learning during the intervention, even as the magnitude of that learning differed by modality.

To determine whether post-test achievement was associated with instructional modality after accounting for pre-test achievement, a baseline-adjusted model was conducted. Although the initial conventional ANCOVA model showed a significant group effect, subsequent assumption analysis revealed that the homogeneity-of-regression-slopes assumption was not satisfied. Specifically, the interaction between pre-test achievement and instructional group was statistically significant, $F(1, 96) = 13.402$, $p < .001$, partial $\eta^2 = .123$. Within the general linear model predicting post-test mathematics achievement, the corrected model was significant, $F(3, 96) = 290.692$, $p < .001$, partial $\eta^2 = .901$, and the individual predictors were likewise significant: pre-test, $F(1, 96) = 590.149$, $p < .001$, partial $\eta^2 = .860$; instructional group, $F(1, 96) = 54.318$, $p < .001$, partial $\eta^2 = .361$; and the pre-test by group interaction, $F(1, 96) = 13.402$, $p < .001$, partial $\eta^2 = .123$. The model accounted for a substantial proportion of variance in post-test scores, with $R^2 = .901$ and adjusted $R^2 = .898$. Because the pre-test by group interaction was statistically significant, the homogeneity-of-regression-slopes assumption required for conventional ANCOVA was not satisfied, and this significant interaction indicates that the relationship between pre-test and post-test performance differed between the Printed Module and Mobile Application groups. Accordingly, the interaction itself, rather than the

group main effect considered in isolation, is central to the adjusted interpretation of these results.

An additional assumption check was undertaken using Levene's test of equality of error variances, which was also statistically significant, $F(1, 98) = 11.474$, $p = .001$. This result indicates unequal error variances between the instructional groups, meaning that the homogeneity-of-variance assumption underlying the conventional general linear model was not satisfied. Because the two groups were equal in size, the analysis remains informative; however, the results should be interpreted with appropriate caution and would ideally be supplemented with a robust sensitivity analysis in future work.

Taken together, these findings provide three major insights that address the objectives of the present study. First, the two groups demonstrated statistically equivalent pre-test performance, with the Printed Module group obtaining a mean of 39.62 and the Mobile Application group obtaining a mean of 39.78, and no statistically significant difference between groups, $t(98) = -0.081$, $p = .935$. This baseline similarity strengthens the internal comparison because the groups did not differ significantly on the measured initial mathematics assessment. Second, both groups demonstrated substantial improvement following instruction, but the Mobile Application group achieved the higher observed post-test performance and the greater mean learning gain, improving by approximately 45.74 points compared with approximately 35.52 points for the Printed Module group, with an observed difference in post-test performance of approximately 10.4 points. This pattern is broadly consistent with the wider literature on technology-enhanced mathematics instruction. Young's second-order meta-analysis reported a moderate cumulative effect of technology-enhanced mathematics instruction across approximately three decades of research and emphasized the importance of the instructional functionality of technology rather than the mere presence of a digital tool. Similarly, Hillmayr et al. (2020) found a positive overall effect of digital tools on mathematics and science learning, with an overall Hedges' g of 0.65 across 92 studies, and their findings suggested that digital tools are often most beneficial when they complement rather than simply replace conventional instruction and when learners receive appropriate instructional support. Ran et al. (2022) offer further explanation for the present findings, as their meta-analysis showed that the effectiveness of technology varies according to its instructional function, with effects particularly favorable when technology supported collaborative and communicative environments, problem solving, conceptual development, and adaptive mathematics practice. The present findings are also consistent with recent mobile-learning research; Garzón et al. (2025) synthesized 253 empirical studies involving more than 21,000 participants and found an overall positive effect of mobile learning on student learning gains, while also emphasizing substantial heterogeneity across studies. This heterogeneity is important because it suggests that positive outcomes cannot be attributed to mobile devices alone, but rather to the design and implementation of the learning experience itself.

Third, and most importantly, the present study identified a significant interaction between pre-test achievement and instructional modality, $F(1, 96) = 13.402$, $p < .001$, partial $\eta^2 = .123$. This result requires a more nuanced interpretation than a simple statement that the mobile application was better than the printed module. The significant interaction indicates that the association between students' initial mathematics achievement and their post-test performance differed across instructional modalities, meaning that the relationship between what students knew before instruction and how they performed afterward was not the same in the two groups. This finding carries potentially important implications for technical mathematics instruction, since students enter higher education with differing levels of prior mathematical knowledge, and a mobile learning environment may offer greater opportunities for repetition, self-pacing, and immediate response to errors, potentially making it particularly useful for learners who need additional practice. However, because the present study did not

directly measure students' use of individual application features, engagement, time-on-task, or learning strategies, such explanations remain hypotheses rather than demonstrated mechanisms. The interaction result also illustrates why statistical adjustment must be undertaken carefully, since a conventional ANCOVA assumes that the relationship between the covariate and outcome is sufficiently similar across groups, and because the pre-test by group interaction was significant, that assumption was not met in the present data. Baseline-adjusted analyses should therefore not be reduced to a single adjusted group effect, and baseline and follow-up methodology emphasizes the importance of appropriate modeling of baseline measurements rather than treating them as an afterthought. The significant Levene test likewise requires caution, as the unequal error variances indicate that the assumptions of the conventional general linear model were not completely satisfied, and the present findings should therefore be interpreted as evidence of a strong association between instructional modality, initial achievement, and post-test performance rather than as definitive proof of a uniform causal effect of MathTech.

Nevertheless, the convergence of these findings is noteworthy. The two groups began with statistically similar measured achievement, both groups improved substantially following instruction, the Mobile Application group achieved a higher observed post-test mean, and the gain scores favored the Mobile Application group. Taken together, these results provide promising evidence supporting MathTech as a supplementary instructional resource for technical mathematics, and they directly address the objectives of the present study by clarifying not only whether the mobile application was associated with higher achievement but also how that association was shaped by students' initial proficiency. These findings have several implications for mathematics instruction in industrial technology programs. Mobile applications can provide a useful supplement to conventional mathematics teaching, and rather than replacing teachers or printed resources, MathTech can provide additional opportunities for practice and review. Mobile learning may be particularly useful for courses containing procedural and symbolic content, since Mathematics for Technologists includes measurement, unit conversion, algebraic manipulation, geometry, trigonometry, and logarithmic functions, all of which require repeated practice. The significant pre-test by group interaction suggests that instructors should consider students' initial mathematics proficiency when integrating digital learning, and diagnostic assessment can help instructors identify students who need remediation, additional practice, or more advanced activities. The expert-validation results further provide evidence that the instructional materials were appropriately developed, although future iterations should continue to evaluate not only content and technical quality but also usability, accessibility, engagement, and actual patterns of student interaction. Collectively, these findings contribute to the growing body of evidence on technology-enhanced mathematics instruction by demonstrating both the promise and the complexity of integrating mobile applications into technical mathematics curricula, and they set the stage for the concluding chapter, which synthesizes these results into broader conclusions and recommendations for instructional practice and future research.

CONCLUSION

This study investigated the effectiveness of MathTech, a curriculum specific mobile application designed for Mathematics for Technologists, in comparison with a traditional printed instructional module among industrial technology students. The findings indicate that both instructional modalities were associated with substantial improvement in mathematics achievement, as the two groups demonstrated comparable pre-test performance, suggesting

broadly similar measured levels of initial achievement prior to intervention. Following instruction, students who used MathTech achieved a higher observed post-test mean and a greater average learning gain than students who used the printed module, lending initial support to the value of the application as an instructional resource.

The most important statistical finding, however, was the significant interaction between pre-test achievement and instructional modality. This interaction, $F(1,96) = 13.402$, $p < .001$, partial $\eta^2 = .123$, indicates that the relationship between initial mathematics achievement and post-test performance differed across the two instructional modalities. Consequently, the findings do not support interpreting MathTech as having one uniform effect for every student; rather, its effectiveness appears to depend, at least in part, on students' prior achievement level. Taken together, these results provide promising evidence that a curriculum aligned mobile application can serve as an effective supplementary resource in technical mathematics education. This is consistent with broader research demonstrating positive effects of technology enhanced mathematics instruction and mobile learning, while simultaneously reinforcing the importance of instructional design, learner characteristics, and implementation context in determining outcomes.

Because the study used a quasi-experimental design and several statistical assumptions were not fully satisfied, the findings should not be interpreted as definitive causal evidence. Nevertheless, the convergence of baseline equivalence, substantial learning gains, higher observed post-test achievement, and a significant instructional-modality interaction provides a strong basis for further investigation of MathTech in technical and higher education mathematics settings.

In light of these findings, several recommendations are proposed to guide both instructional practice and future research. Faculty members teaching Mathematics for Technologists may use MathTech alongside classroom instruction and printed materials rather than treating it as a complete replacement for established teaching practices, since technology should complement rather than replace teacher guidance; evidence from technology enhanced mathematics research suggests that instructional support and appropriate integration remain important conditions for effective digital learning. Furthermore, because the pre-test by group interaction was significant, instructors should consider students' initial mathematics achievement when implementing mobile learning activities, tailoring support to accommodate varying levels of readiness. Future versions of MathTech should also be enhanced to include immediate feedback, worked solutions, progressive difficulty, error analysis, progress monitoring, and opportunities for repeated practice, so as to more directly address the diverse needs of learners.

With respect to future research, statistical models that explicitly accommodate heterogeneous regression slopes and unequal variances should be employed to more accurately capture the differential effects observed in this study. Replication involving larger samples and students from multiple institutions and industrial technology programs would strengthen the generalizability of these findings, while random assignment would further strengthen causal inference concerning the effect of MathTech. In addition, future studies should measure retention several weeks or months after the intervention to determine the durability of learning gains, and should also examine frequency of application use, time-on-task, perceived usability, motivation, and student engagement as potential explanatory factors. Finally, future research should compare printed instruction, mobile application instruction, printed and mobile blended instruction, and conventional teacher-led instruction supplemented by MathTech, in order to more precisely determine the conditions under which curriculum-aligned mobile applications such as MathTech can most effectively enhance mathematics achievement among industrial technology students.

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