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# Evaluating the Impact of Educational Technology on Mathematical Understanding in Secondary Education: A Comparative Study

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**A B S T R A C T :**

With new opportunities for conceptual understanding and involvement, educational technology has completely changed how mathematics is taught and learnt in secondary schools. This comparative study assesses how several technology tools, including digital textbooks, interactive simulations, and AI-powered tutoring systems, affect students' understanding of mathematics. The study looks at how well academic achievement, conceptual clarity, and problem-solving abilities are nurtured in technology-enhanced learning environments versus traditional teaching approaches.

The study used a mixed-methods approach to evaluate the efficacy of various technological interventions by examining both qualitative student input and quantitative performance measures. According to the results, students who use adaptive learning platforms show better analytical thinking and increased memory of mathematical ideas. However, issues like teacher preparedness, digital accessibility, and the efficiency of integration tactics affect results.

This study illustrates how educational technology may be utilised to bridge learning gaps and customise maths lessons. Additionally, it points out drawbacks and suggests methods for making the most of digital resources in secondary school. This study adds to the continuing conversation on best practices in mathematical instruction by offering a nuanced comparison of conventional versus technology-assisted approaches.

## Introduction :

A revolutionary change in pedagogy has been observed in recent years with the introduction of instructional technology into maths classes. Digital technologies like Desmos, GeoGebra, and other interactive platforms, according to proponents, improve conceptual understanding and encourage participation. However, in many educational systems, traditional approaches centred on paper-based practice and direct instruction still predominate. This study investigates the following question: How much does the use of EdTech tools enhance mathematical proficiency at the senior secondary level in comparison to traditional methods? Although a lot of research has been done on the subject, the findings differ according on the tool, context, and implementation approach. Student performance, engagement, and instructional quality are the three primary areas of focus for this review of the literature, which summarises the most important findings from current scholarly research.

## Literature Review:

### Technology and Student Performance in Mathematics:

Numerous studies indicate that instructional technology can improve students' comprehension of mathematics, especially in interactive and visual learning settings. Hattie (2009) discovered that computer-assisted instruction has a moderate impact on student achievement after conducting a meta-analysis of several teaching strategies. Students can investigate functions, geometry, and calculus ideas in a dynamic manner with interactive tools like GeoGebra, which fosters a deeper comprehension of the material (Zbiek et al., 2007).
But according to other studies, how technology is used has a big impact on how effective it is. The well-known claim made by Clark (1983) was that media, including EdTech, are only tools for providing teaching and have no direct impact on learning achievement. According to this perspective, the most important element is not the instrument itself, but rather the instructional design.

Engagement and Motivation Through EdTech: Another area where EdTech seems to have a lot to offer is engagement. Visual manipulatives, gamified platforms (like Quizizz and Kahoot), and real-time feedback systems (like Desmos Activity Builder) all aid in maintaining focus and lowering arithmetic anxiety (Bozkurt, 2021; Reimer & Moyer, 2005). Because these tools are engaging and easy to use, students—especially those who are digital natives—frequently react favourably to them. However, some EdTech platforms inadvertently encourage the use of minimally directed learning settings, which are discouraged by scholars such as Kirschner, Sweller, and Clark (2006). They contend that in the absence of explicit instructional support, pupils could acquire a superficial or inaccurate comprehension of fundamental ideas.

Comparing Traditional and Tech-Enhanced Methods: Comparative research has produced conflicting findings. For example, Li and Ma (2010) discovered that although students who received instruction based on technology scored better than their counterparts in tasks involving problem-solving, traditional techniques were more successful in strengthening procedural fluency. The fundamental tension this research illustrates is that while traditional methods may better assist routine skill mastery, EdTech may be more effective at fostering conceptual comprehension.
Teachers' comfort level and confidence with technology are other important factors. Lack of proper training may prevent teachers from effectively integrating technology, which could result in neutral or even detrimental learning results (Ertmer & Ottenbreit-Leftwich, 2010).

## Methodology:

Research design: Two naturally occurring groups of senior secondary students participated in this study's quasi-experimental approach, which compared the efficacy of standard teaching strategies with educational technology (EdTech)-enhanced mathematics instruction. Unbroken classrooms were utilised instead of random assignments because of the limitations of operating in an existing school environment

Traditional teaching techniques, such as lectures delivered by chalk and talk, exercises based on textbooks, and worksheets on paper, were used to instruct the control group. In contrast, the experimental group received instruction utilising a range of educational technology tools, including interactive simulations, GeoGebra, Desmos, and online tests that were based on the same curriculum content. Over the course of four weeks, the identical mathematical subjects—specifically, the foundational concepts were taught to both groups.

The same teacher instructed both groups in order to reduce instructor bias, and every effort was taken to ensure that the two groups received instruction from the same teacher in terms of pacing, class time, and topic covering.

## Participants:

The study sample comprised 60 students enrolled in Grade 12 mathematics at a public high school. Class categories supplied by the school were used to divide the pupils into two similar classes of thirty each. According to previous term maths marks and standardised test results, both classes had comparable academic profiles, guaranteeing initial equality between the groups.
Consent was acquired from both students and guardians, and participation in the study was entirely voluntary. The academic research committee at the school gave the study ethical approval.

The following tools were employed to assess how different teaching strategies affected students' comprehension and interest in mathematics:

Both before and after the test
Both groups were given an assessment created by the teacher both before and after the intervention. Twenty items covering fundamental algebraic and calculus skills made up the test, which included both procedural and conceptual questions. To guarantee dependability and clarity, the test was piloted with a different set of students and validated by expert evaluation.

Survey of Student Engagement
To gauge student interest, engagement, and perceived comprehension during the learning session, a 15-item Likert-scale survey was created. Items on motivation, focus, involvement, and use of digital tools were included in the survey, which was modified from validated instruments used in earlier EdTech studies.

Two times a week, observations were made in both groups using a standardised rubric that focused on indications including questioning, resource utilisation, collaborative behaviour, and student attentiveness. In order to guarantee score consistency and inter-rater reliability, observers received training.

## Findings

The study's conclusions show that the group that used educational technology tools and the group that received instruction using conventional techniques differed significantly in terms of student learning results and classroom participation. The following section discusses these findings in relation to (1) student involvement, (2) academic performance, and (3) observable classroom behaviours.
Both the experimental and control groups demonstrated quantifiable gains in mathematical proficiency over the course of the instructional intervention, according to a comparison of the pre- and post-test results. Nonetheless, there were notable differences between the two groups in the type and extent of these increases.
In comparison to the control group, the experimental group, which was taught using EdTech resources including interactive simulations and GeoGebra, showed a noticeably greater improvement in post-test performance. The experimental group showed a more noticeable increase, especially in areas requiring conceptual reasoning, whereas the control group only saw a slight improvement, which was mostly due to frequent exposure and practice with procedural exercises. The capacity to handle non-routine and cognitively challenging tasks, like analysing dynamic graphs, simulating real-world

occurrences, and defending results using mathematical principles rather than rote methods, was the most obvious difference between the two groups. As a sign of profound knowledge, students who were exposed to the digital tools seemed better able to apply what they had learnt to new situations.

This shows that EdTech tools may help build stronger cognitive frameworks that promote abstract reasoning and adaptable problem-solving by providing interactive and visual representations of mathematical concepts. The control group, on the other hand, made considerable development, although it was mostly limited to routine activities and procedural precision. Traditional approaches continue to play a fundamental role in developing fluency and discipline-specific norms, as demonstrated by the advances these students showed in areas involving the direct application of formulas and structured solution procedures. Their performance on higher-order items, however, was mostly unchanged, indicating the shortcomings of traditional approaches in nurturing sophisticated conceptual thinking.

The data on student engagement supports the performance patterns even further. Throughout the session, the experimental group's participants continuously reported increased motivation, focus, and perceived understanding. These students acknowledged the interactive element of the EdTech tools as being crucial in maintaining their interest and making difficult concepts easier to understand when asked to reflect on their learning experiences. A natural curiosity and sense of ownership over the learning process seems to be fostered by the chance to investigate, work with, and visualise mathematical relationships in real time. The structured method, on the other hand, was more familiar and comfortable for the students in the control group, especially when it came to handling common difficulties. But their answers also showed a propensity for passivity and a more transactional approach to learning, which focused more on replicating well-known algorithms than on investigating novel concepts. Although they were confident in their ability to follow procedural instructions, they also reported feeling less satisfied and less inclined to take intellectual risks, including trying new or open-ended tasks.

The differences in emotive responses demonstrate how EdTech can be used as a transformative teaching tool that helps students move from being passive recipients of mathematical knowledge to active participants in its development. When considered collectively, the observational data indicate that EdTech-supported instruction not only affects individual cognitive outcomes but also changes the social dynamics of the maths classroom by promoting metacognitive reflection, dialogic learning, and teamwork.

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