OPEN ACCESS

Middle East Research Journal of Humanities and Social Sciences
ISSN 2789-7761 (Print) | ISSN 2958-2040 (Online)
Frequency: Bi-Monthly
DOI: https://doi.org/10.36348/merjhss.2025.v05i04.004

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Leveraging Information Technology to Enhance Mathematics Instruction in Secondary Schools: A Case Study of Three Schools in Kisii County, Kenya

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Abstract: The integration of Information Technology (IT) into mathematics instruction remains underutilized in many rural Kenyan secondary schools despite global evidence supporting its effectiveness. This study investigated how IT tools are used in the teaching of mathematics in three selected secondary schools in Kisii County. Using a mixed-methods approach, data were collected through interviews with teachers, classroom observations, and analysis of student performance records. Results indicated that although IT tools like projectors, educational software, and mobile applications are available in some schools, their integration into daily instruction is limited due to infrastructural, training, and pedagogical constraints. The study recommends targeted teacher training, increased investment in IT infrastructure, and curriculum redesigns to support effective technology use in mathematics instruction.

Keywords: Information Technology, Mathematics Education, ICT in Schools, Kisii County, Secondary Education, Kenya.

Research Paper

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How to cite this paper:
Wilfred Mogire Monyoro (2025). Leveraging Information Technology to Enhance Mathematics Instruction in Secondary Schools: A Case Study of Three Schools in Kisii County, Kenya. *Middle East Res J. Humanities Soc. Sci, 5*(4): 124-129.

Article History:
| Submit: 03.07.2025 |
| Accepted: 02.08.2025 |
| Published: 16.08.2025 |

INTRODUCTION

In today's educational landscape, the integration of Information Technology (IT) into teaching and learning processes is no longer a luxury but a pedagogical necessity. Globally, IT has revolutionized instructional delivery, enhancing learner engagement, facilitating individualized instruction, and improving outcomes in subjects traditionally viewed as difficult particularly mathematics (Kousa *et al.,* 2021; Uluyol & Şahin, 2020). With its inherent need for abstraction, problem-solving, and visualization, mathematics instruction benefits significantly from tools such as computer algebra systems, simulations, dynamic geometry software (e.g., GeoGebra), and virtual manipulatives (Papadakis *et al*., 2021).

Governments worldwide have initiated various programs to support digital transformation in schools. In Kenya, the Ministry of Education, through the Digital Literacy Programme (DLP), has made strides to introduce IT tools in public schools (Tuitoek & Oundo, 2020). These efforts are complemented by the Competency-Based Curriculum (CBC), which emphasizes digital literacy as a core competency (Kenya Institute of Curriculum Development [KICD], 2021). Despite these policy efforts, the uptake of IT in classroom instruction remains uneven. Many secondary schools, especially those in rural and resource-constrained areas, face infrastructural limitations, limited teacher training, and misalignment between curriculum demands and available digital resources (Chege & Mwaura, 2021; Kihara & Ngugi, 2023).

In mathematics instruction, this disparity is particularly concerning. While digital tools have been shown to improve conceptual understanding and learner motivation (Papadakis *et al*., 2021), their actual use in day-to-day teaching remains limited in most Kenyan classrooms. Studies have found that a significant number of teachers continue to rely on traditional chalk-and-talk methods, often citing lack of digital content, minimal training, or inadequate infrastructure as key barriers (Mwangi & Otieno, 2022). Furthermore, most empirical research on digital integration in Kenya has focused on primary education or general ICT usage, with minimal attention paid to secondary mathematics education.

In Kisii County, where schools vary widely in terms of digital infrastructure, academic performance,

and teacher preparedness, the situation is particularly under-documented. While some schools may have access to computers and internet connectivity, there is limited evidence on whether and how these resources are used effectively in teaching mathematics. Additionally, students' perspectives on digital learning tools in mathematics instruction have been largely unexplored.

This study therefore addressed a critical gap by exploring the extent to which IT is integrated into mathematics teaching in selected secondary schools in Kisii County. It examined the tools available, the pedagogical practices of teachers, and the perceptions of students toward IT-enhanced learning. By focusing on a specific subject (mathematics), level (secondary), and locale (Kisii County), the study aimed to provide nuanced insights into the challenges and opportunities that exist in implementing IT in mathematics instruction.

Problem Statement

In the 21st century, the integration of information technology (IT) in education has become a cornerstone of effective teaching and learning, particularly in subjects like mathematics where visualization, modeling, and simulation can enhance conceptual understanding (Kafyulilo & Mgema, 2020; Ezenwosu *et al*., 2021). Globally, digital tools such as interactive whiteboards, mathematics software (e.g., GeoGebra), and e-learning platforms are increasingly being used to promote learner engagement and improve performance outcomes (Donkor, 2022; Haruna *et al*., 2020). However, in the Kenyan context, the adoption of IT in mathematics classrooms remains inconsistent and underexplored, especially in rural and semi-rural counties such as Kisii.

Despite national efforts like the Digital Literacy Programme (DLP) introduced by the Government of Kenya to integrate technology into teaching (Ministry of ICT, 2020), many secondary school teachers continue to rely on conventional chalk-and-board methods. This reliance is often attributed to insufficient infrastructure, lack of pedagogical training in digital tools, and a curriculum structure that is slow to accommodate technological integration (Okoth & Ondiek, 2021; Njenga *et al*., 2023). Furthermore, anecdotal evidence suggests that even in schools with access to ICT resources, these tools are either underutilized or used in ways that do not align with best practices in digital pedagogy (Odongo & Ochieng, 2022).

In Kisii County specifically, disparities in school resources and teacher competencies are prominent due to socio-economic inequalities, yet little empirical research has been conducted to assess the status of IT use in teaching mathematics. While prior studies have addressed general ICT integration in education (Mugo *et al*., 2020), there is a notable gap regarding subject-specific application particularly in mathematics, where the nature of content delivery could benefit most from technological affordances (Yusuf & Ouma, 2021).

This study therefore sought to fill this gap by providing contextual, data-driven insights into how IT is currently being used in mathematics instruction across three public secondary schools in Kisii County. It investigated the types of digital tools employed, challenges experienced by teachers and students, and the potential of IT to enhance learner engagement and academic performance in mathematics.

Objectives of the Study

i. To determine the extent to which IT tools are integrated in mathematics instruction in selected secondary schools.
ii. To identify challenges that hinders the effective use of IT in teaching mathematics.
iii. To evaluate the perceived impact of IT integration on students' engagement and academic performance.

LITERATURE REVIEW

Globally, the integration of information technology (IT) in education has transformed pedagogical approaches and enhanced student learning outcomes, particularly in subjects that require visualization and abstract reasoning like mathematics (Henderson & Romeo, 2021). Educational technologies ranging from interactive whiteboards to mathematics-specific software such as GeoGebra and Desmos have been widely recognized for their ability to support conceptual understanding, foster active learning, and promote autonomy in learners (Yusuf & Alabi, 2022). These digital tools offer interactive features that allow students to manipulate variables, explore relationships between mathematical functions, and visualize complex equations in real time, enhancing both engagement and comprehension.

In developing countries, however, the integration of IT into classroom instruction remains uneven. In many Sub-Saharan African contexts, including Kenya, schools face persistent challenges such as underdeveloped infrastructure, inadequate teacher training, and low access to relevant digital content (Muthoni & Kiplangat, 2021). While Kenya's Ministry of Education has launched policy initiatives like the Digital Literacy Programme (DLP) and the Competency-Based Curriculum (CBC), which advocate for the use of IT in teaching and learning, implementation has been hampered by resource disparities and institutional limitations (Tuitoek & Oundo, 2020).

Recent studies in Kenya emphasize the potential of IT to improve mathematics instruction. For instance, Otieno and Achieng (2021) found that students exposed to digital simulations and interactive mathematics platforms showed improved attitudes and performance in algebra and geometry. Similarly, Moraa

and Kilel (2022) reported that tools such as Desmos enabled students to explore functions more intuitively compared to traditional chalkboard instruction. These studies highlight that, when effectively utilized, IT can bridge learning gaps and enhance conceptual understanding.

Despite these documented benefits, several obstacles continue to impede the widespread adoption of IT in Kenyan classrooms. Njoroge and Wambugu (2020) identified critical barriers such as unreliable electricity, limited internet connectivity, and lack of sustained professional development for teachers. Otieno and Wanyama (2022) further reported that even in schools equipped with IT resources, only about 32% of mathematics teachers integrated digital tools regularly, citing lack of confidence, insufficient pedagogical training, and incompatibility with the existing syllabus.

However, these findings are often generalized across wide regions, failing to capture the micro-contexts of specific counties or sub-counties. Kisii County, for example, presents a unique setting where disparities in school resources, teacher readiness, and student access to digital tools may significantly affect IT adoption in mathematics instruction. Yet, empirical studies focusing specifically on this region are limited. Most existing research either concentrates on urban settings or aggregates data at the national level, overlooking localized challenges and success stories that could inform context-sensitive interventions.

This study, therefore, addressed a critical gap in the literature by focusing on the integration of IT in mathematics instruction within three public secondary schools in Kisii County. It examines the current state of IT usage, identifies institutional and pedagogical barriers, and explores students' and teachers' perceptions of technology-enhanced learning. By doing so, the study aims to offer targeted recommendations for improving IT integration tailored to the realities of rural secondary schools in western Kenya.

METHODOLOGY

Research Design

This study adopted a mixed-methods case study design to explore the integration of information technology (IT) in the teaching of mathematics in secondary schools. The mixed-methods approach enabled the researcher to triangulate both qualitative and quantitative data, thereby enhancing the validity and comprehensiveness of the findings (Creswell & Creswell, 2023). Case study methodology was appropriate because the focus was on a detailed contextual analysis of specific schools within Kisii County.

Study Site and Participant Selection

Three public secondary schools in Kisii County, Kenya, were purposively selected for this study. Selection criteria included the schools' geographical accessibility, academic performance in mathematics, and the availability of basic IT infrastructure such as computer labs or internet connectivity. The study involved a total of 69 participants, comprising six mathematics teachers (two from each school), three ICT coordinators (one per school), and 60 Form Three students (20 from each school). Purposeful sampling ensured that participants had relevant experiences with IT tools in mathematics instruction.

Data Collection Instruments

Multiple instruments were used to collect data in order to ensure depth and reliability of findings. These included:

Questionnaires: Structured questionnaires were administered to both teachers and students. The teacher questionnaire assessed the frequency, type, and perceived effectiveness of IT use in mathematics instruction, while the student version explored learners' experiences and attitudes toward digital tools in mathematics learning.

Interviews: Semi-structured interviews were conducted with mathematics teachers and ICT coordinators. These interviews explored perceptions of digital integration, institutional challenges, and support structures available for technology-enhanced instruction.

Classroom Observations: Direct observations were carried out during mathematics lessons to document actual use of IT tools, pedagogical strategies, and student engagement. An observation checklist guided the process, focusing on the type of technology used, duration of use, and interaction patterns.

Document Analysis: Supplementary data were collected through the analysis of teaching schemes of work, lesson plans, digital teaching materials, and student performance records in mathematics.

Data Analysis Procedures

Quantitative data collected from questionnaires were coded and analyzed using IBM SPSS Statistics Version 27. Descriptive statistics such as frequencies and percentages were computed to determine trends in IT usage, while cross-tabulations explored variations across the three schools. Qualitative data from interviews, observations, and document reviews were analyzed thematically. This process involved reading transcripts multiple times, coding emerging concepts, and organizing codes into thematic categories such as "infrastructure gaps," "teacher readiness," and "student engagement with IT."

Integration of the findings from both data types was performed during the interpretation phase, allowing for a nuanced understanding of the research problem. The use of methodological triangulation strengthened the credibility and depth of the results (Patton, 2015).

RESULTS

Information Technology Integration in Instruction

The analysis of classroom observations and interviews with six mathematics teachers revealed minimal integration of information technology (IT) tools into mathematics instruction. As shown in Table 1, only two teachers reported using PowerPoint presentations occasionally to display lesson notes and examples. One teacher incorporated GeoGebra during geometry lessons to demonstrate transformations and geometric constructions. Notably, none of the teachers used educational videos, simulations, or learning management systems. The majority relied heavily on traditional methods such as textbook instruction and verbal explanations.

Table 1: Frequency and Mode of Information Technology Use in Mathematics Instruction (n = 6 Teachers)

IT Tool or Strategy Used	Frequency of Use	Description of Use Context
PowerPoint Presentations	Occasionally (2)	Used to display notes and examples in select lessons.
GeoGebra	Rarely (1)	Used for teaching geometric constructions and graphs.
YouTube/Video Lessons	None (0)	Not used by any of the teachers.
Learning Management Systems	None (0)	No LMS integration observed.
Traditional Methods (Textbooks, Verbal Explanation)	Regularly (6)	Main mode of instruction used by all teachers.

Note: Most teachers relied on traditional instructional methods. Only limited use of IT tools was observed, with minimal integration into regular lesson planning.

These findings align with prior studies indicating that while digital tools are increasingly recognized for enhancing conceptual understanding, their actual adoption in sub-Saharan African classrooms remains low (Becta, 2021; Mlambo *et al*., 2020). The lack of consistent use of tools such as GeoGebra, dynamic graphing software, or mathematics-specific simulations suggests that IT has yet to be embedded meaningfully into everyday mathematics instruction in these schools.

Challenges to Technology Integration

Teachers reported several interrelated barriers hindering the effective use of technology in their classrooms. As summarized in Table 2, these include limited infrastructure, inadequate training, and lack of curricular support. Only one of the three schools had a functioning computer laboratory with stable internet access. Even in that school, computers were shared across departments, reducing scheduling flexibility for mathematics lessons.

Table 2: Identified Barriers to IT Integration in Mathematics Classrooms

Barrier Category	Observation Details
Infrastructure	Only one out of the three schools had a functional computer lab with reliable internet.
Teacher Training	Teachers reported lacking formal training in ICT-based pedagogy or digital content creation.
Curriculum Constraints	Schemes of work and syllabi did not incorporate or require digital tools or software.
Technical Support	No dedicated ICT technician was available to support teachers during lessons.
Time Constraints	Teachers reported limited lesson time to incorporate technology meaningfully.

Note: These barriers reflect systemic challenges affecting digital integration in instruction, limiting even willing teachers from using IT tools effectively.

These findings are consistent with those of Kafyulilo and Fisser (2021), who found that infrastructural limitations and lack of teacher preparedness were the most cited obstacles to digital integration in Tanzanian secondary schools. Moreover, when teachers do not perceive curriculum alignment with technology use, their willingness to experiment with digital tools diminishes (Oluoch *et al.,* 2023). The challenge is thus not merely technical, but also pedagogical and systemic.

Impact of IT on Student Engagement

Despite the limited integration of IT in classrooms, students who were exposed to technology-supported lessons expressed heightened engagement and positive attitudes. Table 3 presents responses from 60 secondary school students who participated in the study. An overwhelming 85% reported that mathematics lessons became more interesting when digital tools were used. Additionally, 72% believed IT could enhance their academic performance in mathematics, and 80% indicated a desire for more technology-integrated instruction.

Table 3: Student Perceptions of Information Technology Use in Mathematics Lessons (n = 60)

Perception Statement	Percentage Agreement (%)	Interpretation
"Mathematics becomes more interesting when digital tools are used in lessons."	85%	High engagement when IT is incorporated, even occasionally.
"Using IT can help me perform better in mathematics exams."	72%	Students perceive a performance benefit from digital tools.
"I would prefer more lessons that involve computers or educational videos."	80%	Strong preference for interactive, tech-supported learning.
"Teachers should be trained to use technology in mathematics lessons."	88%	Students believe teacher competence in IT is crucial.

Note: Student responses indicate a strong positive attitude toward IT-supported instruction despite its limited implementation.

These findings suggest that students not only value technology but perceive it as instrumental to their academic success. According to Dlamini and Machaba (2022), technology-enhanced lessons are particularly effective for visual learners and for illustrating abstract mathematical concepts. The strong student demand for more technology use also reinforces the need for teacher professional development and curriculum reform to accommodate modern pedagogical approaches.

Implications for Practice

The data underscore the urgent need for targeted interventions to improve IT infrastructure, teacher training, and digital curriculum alignment in Kenyan secondary schools. Capacity-building programs should prioritize hands-on training with specific mathematics tools like GeoGebra, Desmos, and spreadsheet-based simulations. At the policy level, the Teachers Service Commission and the Ministry of Education should consider incorporating digital pedagogy into pre-service teacher training and CPD (Continuous Professional Development) frameworks.

CONCLUSION

Information Technology holds immense promise for transforming mathematics instruction in Kisii County. However, current usage is sporadic and constrained by infrastructure and training challenges. To unlock IT's full potential, deliberate efforts must be made to empower teachers, equip schools, and align curricula with digital pedagogies.

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