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Predicting AI Readiness and Teacher Motivation in Blended Secondary Mathematics Classrooms

Tola Bekene Bedada

tolaB@wcu.edu.et

Wachemo University

Addise Abame

Wachemo University

Lamecha Gelato

Wachemo University

Jabe Bekele

Wachemo University

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Corresponding author: Tola Bekene Bedada, Email: leencaoro@gmail.com,

Affiliation:Department of Mathematics,Wachemo University,Ethiopia, Orcid:**0000-0003-1828-3582**

Co-Authors

Addise Abame , Email: addiseabame@gmail.com **Affiliation: Department of English Language and Literature,Wachemo University,Ethiopia** Orcid:0000-0001-9264-6252

Abebe Lolamo , Email: tesfahun65@gmail.com **Department of English Language and Literature,Wachemo University,Ethiopia** Orcid:0009-0007-3670-1772

Lamecha Gelato Email: lemechageleto@yahoo.com **Affiliation: Department of Psychology ,Wachemo University,Ethiopia** Orcid:0000-0003-1733-7809

Jabe Bekele Email: jabebekele2003@gmail.com,**Affiliation:** Department of Educational Planning and Management,**Wachemo University,Ethiopia** Orcid: 0009-0000-4308-7693

Abstract

This study investigated the structural relationships between technology-supported instructional tools and teachers' perceptions and motivation among 53 purposively sampled secondary school teachers in Central Ethiopia. While raw data deviated from normality ($p < 0.001$), stable homoscedasticity and safe collinearity diagnostics (VIF range: 1.147–1.249; maximum Condition Index: 20.689) justified ordinary least squares multiple linear regression. The overall regression model was highly significant ($F(3, 49) = 22.648$, $p < 0.001$), explaining 58.1% of the total variance in teacher perception and motivation ($R^2 = 0.581$, Adjusted $R^2 = 0.555$). Individually, the Use of Adaptive Learning Platforms was the strongest unique positive predictor ($\beta = 0.683$, $t = 6.611$, $p < 0.001$), followed by AI-Enhanced Feedback Systems ($\beta = 0.261$, $t = 2.641$, $p = 0.011$). Conversely, Interactive Assessment Tools yielded a non-significant effect ($\beta = -0.146$, $p = 0.155$). Descriptive analyses revealed a pedagogical paradox. Teachers showed strong baseline literacy regarding blended learning concepts (M = 3.72) and GeoGebra (M = 3.85), but operational usage of Google Workspace sat below the neutral midpoint (aggregated M = 2.896). Usage clustered in passive workflows like Gmail (M = 3.19) and YouTube (M = 3.08), while active content-creation systems like Google Forms (M = 2.77) and Slides (M = 2.74) lacked high-frequency deployment.

Systemic policy under the *Digital Ethiopia 2025* initiative must pivot professional development toward active digital content curation and algorithmic orchestration.

Keywords: Blended Learning, Artificial Intelligence, Multiple Linear Regression, Teacher Motivation, Google Workspace, Ethiopian Secondary Education

1. INTRODUCTION

The rapid technological transformation across the globe has rendered the integration of digital technologies into diverse fields, including education, indispensable (Abdulmunem, 2023). Artificial intelligence (AI), in particular, is increasingly shaping instructional practices by enabling automation, adaptive feedback, and personalized learning pathways. These developments are redefining traditional teaching methods, moving education toward more data-driven, interactive, and student-centered approaches. Globally, AI applications in education range from intelligent tutoring systems and automated assessment platforms to collaborative learning tools that foster real-time interaction and feedback(Marouf et al., 2024).

In the African context, educational systems are gradually embracing digital technologies as part of broader efforts to bridge equity gaps and strengthen learning outcomes. However, the continent continues to face challenges related to digital infrastructure, limited teacher preparedness, and disparities in access to technology (UNESCO, 2017). While AI and blended learning hold transformative potential, their success depends heavily on contextual adaptation, policy alignment, and pedagogical integration. Evidence from African studies emphasizes that technological adoption must be accompanied by teacher training, institutional support, and strategies that prioritize inclusion and equity.

Ethiopia, in particular, is at a critical juncture in its efforts to modernize education. The integration of AI technologies into secondary school instruction presents both significant opportunities and challenges. The blended learning model—which combines face-to-face and digital instruction—offers a promising framework for enhancing educational access, effectiveness, and equity. Intelligent Tutoring Systems (ITS), for example, can analyze student performance data, adapt instructional strategies, present targeted exercises, and provide customized guidance, thereby improving learning outcomes and fostering engagement(Marouf et al., 2024). Yet, successful implementation in Ethiopia requires navigating systemic challenges such as infrastructural constraints, curriculum alignment, and the need for continuous teacher professional development (Akintola et al., 2025).

Against this backdrop, the present study investigates the evolving role of AI in Ethiopian secondary education, focusing on its implementation through blended learning strategies. Specifically, it examines how technology-supported instructional practices relate to teacher motivation and pedagogical effectiveness. By generating evidence-based insights, the study seeks to contribute to ongoing debates on how Ethiopia can leverage AI to transform its secondary education system while ensuring equitable, context-sensitive, and sustainable innovation.

1.1. ARTIFICIAL INTELLIGENCE IN CONTEMPORARY EDUCATION

Artificial intelligence (AI), broadly defined, refers to the simulation of human intelligence processes by machines, particularly computer systems. Core aspects of AI involve mimicking human intelligence to perform tasks such as learning, reasoning, problem-solving, and natural language understanding. In education, AI encompasses tools and systems designed to facilitate adaptive learning, content generation, assessment, feedback provision, and intelligent tutoring (Akintola et al., 2025; Opesemowo & Ndlovu, 2024; Paola et al., 2024). One of the most widely applied branches of AI is machine learning, which employs algorithms that improve automatically through experience, thereby offering dynamic and personalized learning opportunities for students.

1.2. THE ROLE OF AI IN BLENDED LEARNING FOR EDUCATION

ADAPTIVE EDUCATION

AI-driven adaptive education systems evaluate student performance data and customise the learning process to meet individual needs, particularly addressing the shortage of trained teachers and limited resources while maximising educational potential(Abbas & Aslam, 2025; Wardat et al., 2024). These systems adjust both the pace and the level of difficulty of content delivery according to a learner's competency and progress.

One widely adopted feature is Dynamic Difficulty Adjustment, where lessons are modified based on a student's mastery level. Platforms such as *DreamBox* and *Knewton* exemplify this approach by diagnosing knowledge gaps and recommending targeted resources, thereby offering personalised science and subject specific training(Akintola et al., 2025). Similarly, personalised learning paths provide students with activities and materials that align with their strengths and weaknesses(Paola et al., 2024; UNESCO, 2017) Another innovation in education is Systems for

Intelligent Tutoring **(**SIT**)**, which deliver individualised guidance and feedback. In Ethiopia, the *E-SHE (e-Learning for Strengthening Higher Education)* programme illustrates this potential. By leveraging AI-driven Intelligent Tutoring Systems (ITS), the programme delivers adaptive feedback and tailored support to university instructors, accounting for their distinct learning needs and styles. This initiative is a collaborative effort involving the Ministry of Education, the Mastercard Foundation, Arizona State University, and Ethiopian public universities.

Scholars consistently emphasise the promise of combining blended learning (BL) with AI to enhance educational outcomes.(Abdulmunem, 2023) highlights the role of adaptive learning systems in AI-supported BL environments, while (Lin et al., 2023) demonstrate that ITS integration improves both student engagement and knowledge retention. Similarly, (Marouf et al., 2024) argue that AI-powered tutoring provides real-time, personalised feedback, significantly boosting student performance.

The impact is particularly notable in mathematics and English education (Opesemowo & Ndlovu, 2024) show that AI-powered platforms, including adaptive learning and automated problem-solving tools, support deeper comprehension of complex mathematical concepts through individualised pathways. Moreover,(Stanković et al., 2025) demonstrate that AI extends beyond routine problems, effectively addressing non-standard mathematics tasks and offering valuable instructional support for both learners and educators.

In sum, adaptive education powered by AI not only enriches learning through personalisation but also holds particular promise for Ethiopia, where integrating these systems into blended learning can bridge teacher shortages, strengthen higher education, and accelerate progress toward equitable and high-quality instruction.

1.3. STATEMENTS OF THE PROBLEM

BLENDED LEARNING IN ETHIOPIA

Blended learning combines online digital media with traditional classroom instruction and has been applied effectively in subjects such as astronomy education (Islam et al., 2022; Kurniawan et al., 2025; Radovan, 2024). This approach promotes flexibility, reduces classroom hours, accommodates diverse learner needs, and is increasingly important for advancing equity in

education. While blended learning is still at an early stage in Ethiopia, particularly in secondary schools, access to digital platforms such as Microsoft Teams and Google Classroom is improving, making AI integration within blended learning more feasible. Globally, many countries have already updated their curricula to integrate AI into classrooms (Wardat et al., 2024).

Ethiopia's education system has undergone several curriculum reforms. The 2018 reform placed greater emphasis on "soft skills" such as ICT, innovation, creativity, and entrepreneurship(Teferra et al., 2018). In line with national digital transformation efforts, the country also launched "Digital Ethiopia 2025", which includes the ambitious *5 Million Coders* initiative led by the Prime Minister. To complement this, the Ministry of Education (MoE) approved the Digital Skills Country Action Plan (DSCAP 2020–2030), which sets out five strategies: (a) establishing enabling policies, digital skills frameworks, and assessments; (b) reforming digital skills programmes; (c) enhancing technology use in teaching and learning; (d) expanding broadband and digital campus services; and (e) building institutional capacity and re-engineering processes.

Despite these policies, a significant gap remains between MoE strategies and teachers' awareness and capacity, both in secondary and higher education. Bridging this gap is crucial if national strategies are to translate into classroom practice. The Ethiopian education system aspires to expand digital tools across all levels, but the digital divide the disparity between those with sufficient access to technology and those without remains a pressing concern (Moore et al., 2018; Mulenga & Shilongo, 2024; Resta et al., 2018). Geographic isolation, resource shortages, and uneven connectivity further exacerbate inequities, particularly between rural and urban schools (Bedada, 2021; Machaba & Bedada, 2022). These divides raise critical questions of fairness in access to education.

Sustainable education in Ethiopia is challenged by inadequate infrastructure, limited teacher training, scarce resources, and low levels of digital literacy. AI-supported blended learning is increasingly seen as a potential solution, with the capacity to personalise learning, improve access, and inform data-driven decision-making (Kurniawan et al., 2025; Lin et al., 2023). However, professional development remains a bottleneck: in training sessions we conducted for secondary school teachers in summer 2024, many participants struggled even with basic ICT operations, such as switching computers on and off or navigating digital assessment platforms.

Despite these challenges, efforts are being made to integrate technology into core learning processes. For example, the MoE has piloted online examinations for Grade 12 students, with Addis Ababa city selected as a trial site. Resources such as laptops, tablets, and exam software have been deployed since 2023/24. At the higher education level, the government's *e-SHE programme* aims to digitise all courses, signalling recognition of the urgent need for technology-enabled education in a global context of crisis and transformation.

Digital platforms such as Google Classroom, GeoGebra Classroom, and other Learning Management Systems (LMS) provide interactive, low-cost, and user-friendly environments that integrate tools like Google Docs, Drive, Gmail, YouTube, Sheets, Slides, and Forms (Abdissa et al., 2025; Islam et al., 2022). These platforms foster active student engagement and support new models of pedagogy. However, the effective use of such tools depends heavily on teacher attitudes and readiness (Bedada, 2024; Wardat et al., 2024). Without this, integration risks remaining superficial.

At present, Ethiopian students are increasingly disengaging from subjects such as mathematics, with many losing knowledge over time despite majoring in the discipline. Scholars argue that AI-enabled blended learning could revitalise interest by supporting personalised instruction and engagement(Stanković et al., 2025) In the modern digital age, however, education systems face mounting pressure to prepare learners for a knowledge-based economy. This requires rethinking pedagogy, assessment methods (online vs. paper-based), and the roles of teachers and students within technology-enhanced environments.

The Ethiopian government has long recognised ICT as central to educational transformation, with national ICT policies introduced in 2009 and 2016. The 2016 strategy specifically identifies education as a pillar for human capital development, emphasising ICT's potential to expand access and improve quality. Nonetheless, actual practice lags behind policy: while some universities, such as Addis Ababa, Gondar, Jimma, and Bahir Dar, employ technology in administrative tasks (e.g., dormitory placement, academic status, and calendars), integrating digital tools into core academic instruction remains a missing practice (Gemechu et al., 2017).

In sum, while Ethiopia has articulated strong policy frameworks for blended learning and digital education, the reality on the ground—characterised by digital divides, teacher readiness challenges, motivation and perception, and infrastructural gaps—illustrates the need for context-sensitive, AI-enhanced strategies that bridge vision and practice.

1.4. OBJECTIVES OF THE STUDY

The objectives of the study were:

1. To identify the technology-supported instructional strategies that most strongly predict teacher motivation and perception in blended learning contexts.
2. To explore how pedagogical training for blended learning is conceptualized and implemented among secondary school mathematics teachers.
3. To investigate the readiness of secondary school mathematics teachers to adopt Artificial Intelligence (AI) and blended learning approaches

1.5. RSEARCH QUESTIONS

The research questions of the study were coined as:

1. Which technology-supported instructional strategies most strongly predict teacher motivation in blended learning contexts?
2. How is pedagogical training for blended learning can be conceptualized and implemented among secondary school teachers?
3. Do secondary school teachers are ready to accept AI and Blended learning for their instruction?

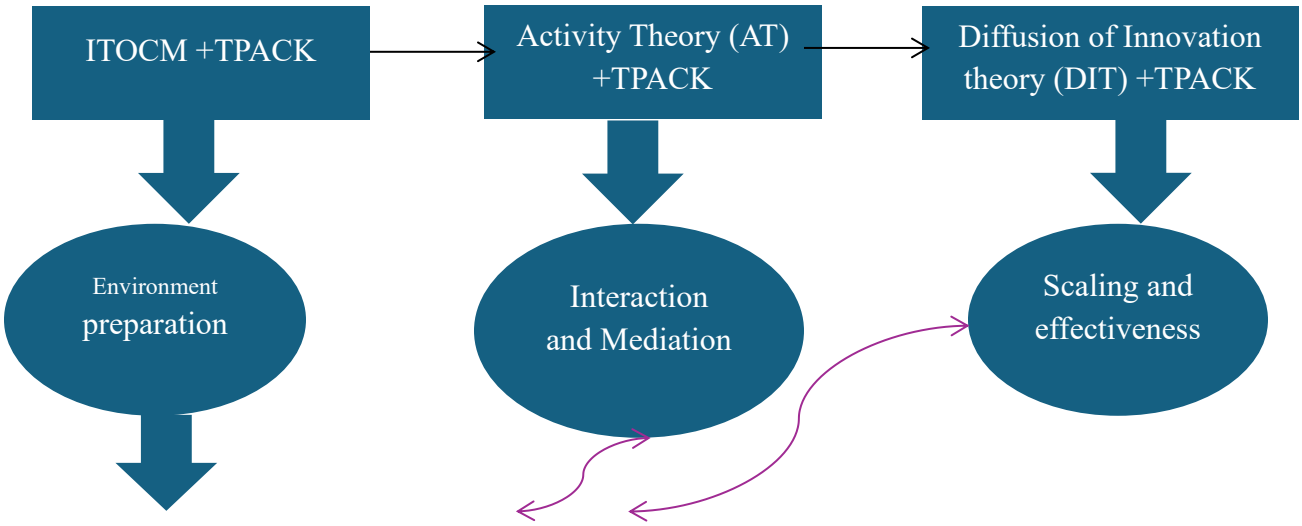
2. THEORETICAL FRAMEWORK: INTEGRATED TECHNOLOGY ADOPTION CYCLE MODEL (ITACM)

This study draws on three theoretical perspectives to develop a proposed model, the Integrated Technology Adoption Cycle Model (ITACM). The first is the Instructional Technology-Oriented Cycle Model (ITOCM), which emphasizes identifying environments conducive to the introduction of technology(Bedada, 2021). The second is Activity Theory, which highlights the importance of

interaction among actors, tools, and contexts in shaping technology use (Ball Anthony, 2012). The third is the Diffusion of Innovation Theory, which focuses on the effectiveness and patterns of technology adoption across individuals and institutions (Ball Anthony, 2012; Kaminski, 2011).

Across these three theories, the TPACK framework (Technological Pedagogical Content Knowledge) is employed to strengthen the integration of pedagogy, content, and technology(Koehler et al., 2013). TPACK provides a unifying lens to ensure that instructional design aligns technological tools with both subject matter and teaching approaches.

The resulting ITACM is conceptualised as a cyclical framework for effective technology adoption in education (CFETA). The cyclical nature of the model underscores the iterative and adaptive process of technology integration, where environments are first identified, interactions are facilitated, and diffusion strategies are applied. Importantly, the sequence of stages within ITACM is critical to reducing risks during implementation. The figure below illustrates the sequential flow of ITACM, which is further discussed in detail in the following section.



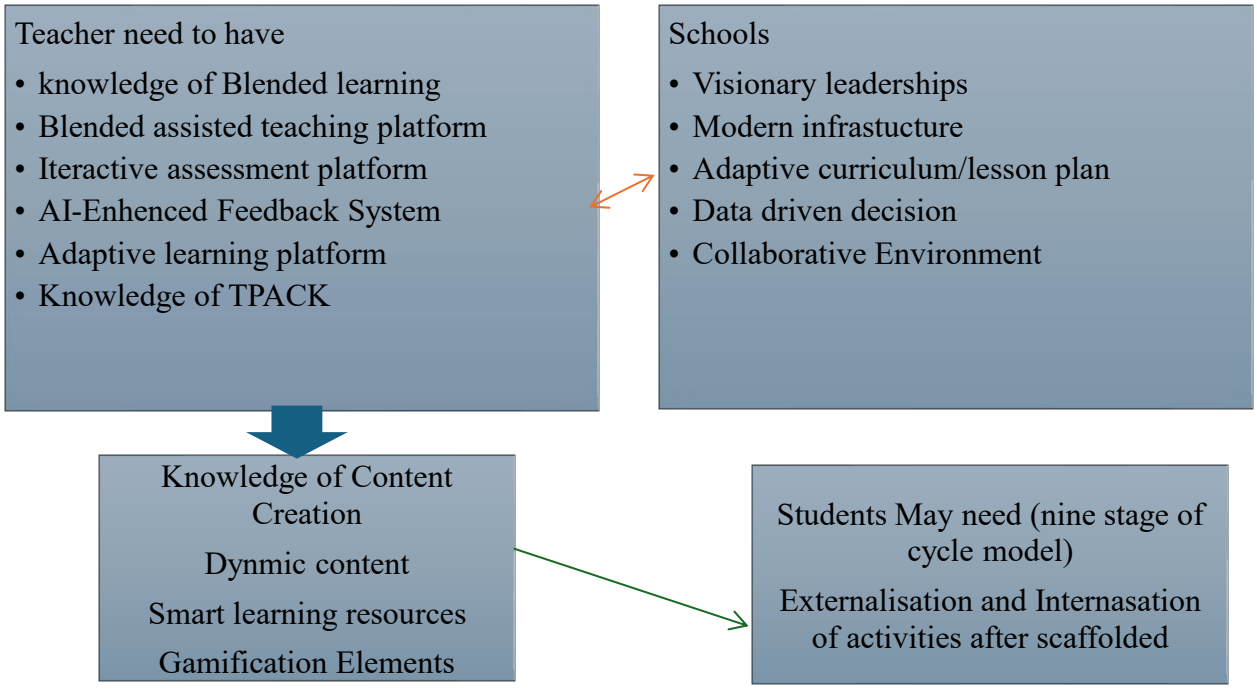


Figure 1: The progressions stages of ITACM in implementing Blended learning

TPACK explains how teachers integrate technology (AI tools) with pedagogical knowledge and content knowledge in blended learning on the topic quadratic functions. It is effective for analyzing teachers' readiness in Technological Knowledge (TK):using AI tools (like GeoGebra, chatbots, adaptive systems), and Pedagogical Knowledge (PK): How to teach constructivist, inquiry-based, blended approaches, and Content Knowledge (CK):topics like quadratic functions, algebra, etc.; and TPACK Intersection: Teachers who successfully combine all three domains are more likely to use AI effectively, competence, and instructional practices in using AI and blended learning(Bedada, 2021). Activity Theory (Engeström's Version): Focuses on systemic interactions between tools (AI platforms), subjects (teachers/students), community (school, policy), and objectives (learning outcomes) which helps to identify challenges and contradictions in the use of AI in real-world Ethiopian classrooms (e.g., infrastructure gaps, policy misalignment). In this we can see the variables such as subject (the teacher or student, and object: Improved learning via AI-enhanced blended learning, and Tools: GeoGebra, Google Classroom, chatbots, adaptive systems, Rules: School policies, curriculum, assessment standards and Community: Teachers, school leaders, policymakers and finally Division of Labor: Roles of AI tools vs. teacher effort.

Diffusion of Innovation Theory (Everett Rogers): Useful for examining how and why AI and blended learning tools are adopted (or resisted) by teachers, schools, and policymakers in Ethiopia. It supports investigating opportunities (early adopters, benefits) and challenges (lack of training, resistance to change).

The integration of AI into the Technological, Pedagogical, and Content Knowledge (TPACK) framework within blended learning environments enhances dynamic, data informed teaching practices. In this expanded model often termed TPACK-AI—AI serves as an adaptive layer that personalizes content delivery across online and face-to-face modalities, analyzes student learning patterns to inform pedagogical strategies, and supports teachers in making real-time decisions about when to deploy technology, direct instruction, or collaborative activities which is indicated in figure1. For example, AI tools can automate routine assessments in the digital space, freeing teachers to focus on higher-order conceptual discussions during in-person sessions, thereby deepening the synergy among content (e.g quadratic equation), pedagogy (pedagogy of Blended learning), and technology (e.g GeoGebra, Chatboots). However, successful integration requires teachers to develop new forms of contextual knowledge, such as understanding AI's limitations, biases, and ethical implications, ensuring that blended practices remain inclusive, transparent, and pedagogically sound. Ultimately, AI-enhanced TPACK transforms blended learning from a structural blend of modes into an intelligent, adaptive ecosystem that continuously aligns technological affordances with pedagogical goals and content demands. The study was used these concepts to analyses the data obtained from the participants of the study.

3. LITERATURE REVIEW

3.1. AI IN EDUCATION: OPPORTUNITIES AND CONCERNS

Recent studies underscore the transformative potential of AI tools—such as chatbots, intelligent tutoring systems, adaptive assessments, and content generation platforms—in education (Mohammed et al., 2025). These technologies can diagnose learning gaps, provide instant feedback, and adjust instructional content based on individual student performance. Generative AI applications like ChatGPT have further demonstrated promise in supporting student inquiry, problem-solving, and conceptual understanding (Rane, 2023).

Despite these benefits, concerns persist regarding over-reliance on AI in classrooms, where deep conceptual learning is essential. Critics warn that without appropriate pedagogical framing, students risk becoming passive recipients of information rather than active constructors of knowledge (Watson, 2025). Passive engagement often results in shallow cognitive processing, with students focusing on rote memorization rather than developing a robust understanding of concepts.

AI, however, also offers unique solutions for equity and inclusion. For instance, the Digital Mathematics Learning Companion (DMLC)—an AI-supported Android platform—was designed as a teaching assistant for blind learners. The application operates through voice commands and tactile input, enabling students with visual impairments to independently access and engage with mathematical learning without constant reliance on specialized instructors(Watson, 2025).

Overall, AI technologies provide a spectrum of potential advantages, including personalised instruction, adaptive assessment, interactive learning environments, and real-time feedback. At the same time, they present significant challenges, such as limited capacity for fostering creativity and problem-solving, inability to explain reasoning, algorithmic bias, lack of emotional intelligence, data privacy concerns, and risks of exacerbating educational inequality(Opesemowo & Adewuyi, 2024; Opesemowo & Ndlovu, 2024).

For Ethiopia, these opportunities and challenges highlight the importance of adopting AI within a carefully designed blended learning framework one that not only leverages AI's adaptive and inclusive potential but also addresses risks of inequity, shallow learning, and infrastructure limitations**.**

3.2. EVOLVING TEACHER COMPETENCIES IN THE 21ST CENTURY

The teaching profession is undergoing rapid transformation in the 21st century, requiring educators to cultivate new competencies and adapt to shifting roles (Sidelil et al., 2023). Beyond classroom instruction, teachers are expected to acquire personal and socio-emotional skills, as well as technical, managerial, and financial competencies, enabling them to respond to globalization, diverse classrooms, and changing societal expectations. In particular, teachers' digital competence now extends well beyond instructional practices, shaping their professional growth and the broader

advancement of educational institutions. As educational systems increasingly integrate digital technologies and AI, teachers must master a wide range of digital skills to effectively facilitate student learning.

3.3. INTERACTIVE ASSESSMENTS IN BLENDED LEARNING

Interactive assessments leverage digital tools, simulations, quizzes, and real-time feedback to engage students and measure learning outcomes in blended learning environments. The rise of generative AI tools such as ChatGPT has further challenged traditional assessment paradigms by introducing opportunities for deeper inquiry while raising concerns about exam integrity. Online assessments also bring additional challenges, such as ensuring identity verification, implementing robust proctoring mechanisms, and maintaining academic honesty in digital environments (Han et al., 2023).

Practical Example: Quadratic Functions

In-Class (Face-to-Face): The teacher introduces the standard form of a quadratic function $f(x) = ax^2 + bx + c$, followed by a sketching activity to review key concepts (vertex, axis of symmetry, discriminant).

Online Interactive Component:

Step 1: **GeoGebra Applet Exploration** – Students manipulate sliders for parameters a, b, and c. The graph updates dynamically, displaying vertex and roots. Embedded questions include: *What happens when a becomes negative? For which values of b and c does the function have one or no real roots?*

Step 2: **Google Forms Quiz** – Linked to the GeoGebra activity, with interpretation questions, analytical tasks (e.g., "If the vertex is (2, –3), find the quadratic equation"), and reflection prompts on the role of a.

Step 3: **Submission & Feedback via Google Classroom** – Students upload short videos explaining their observations. Teachers provide rubric-based digital feedback.

Step 4: **Quizizz** – Applied as a gamified follow-up quiz to consolidate understanding.

3.4. AI-ENHANCED FEEDBACK SYSTEMS IN BLENDED LEARNING

AI-powered systems use **machine learning and natural language processing (NLP)** to provide personalized and timely feedback to students (UNESCO, 2017). Examples include automated essay scoring tools (e.g., Grammarly, Turnitin Revision Assistant), coding platforms (e.g., CodeSignal, HackerRank), and intelligent tutoring systems (e.g., Carnegie Learning). Empirical studies reveal that students receiving AI-generated feedback demonstrate faster performance improvements compared to those relying solely on human feedback(Abbas & Aslam, 2025; Opesemowo & Adewuyi, 2024; Opesemowo & Ndlovu, 2024; Stanković et al., 2025). These systems are particularly effective in large classes, where delivering individualized teacher feedback can be difficult. However, concerns remain about the fairness, transparency, and interpretability of AI feedback, underscoring the importance of teacher mediation.

Practical Example: AI-Enhanced Workflow in Mathematics

Task: Students manipulate GeoGebra sliders for a, b, and c to predict graph behavior.

AI Feedback:

Correct Answer: Immediate confirmation (e.g., *"Correct! When $a < 0$, the parabola opens downward."*).

Incorrect Answer: AI generates hints (e.g., *"Try selecting different values of a. What do you observe?"*).

Misconception Detection: If a student consistently misinterprets graph orientation, the system flags the error and suggests remediation.

3.5. ADAPTIVE LEARNING PLATFORMS (ALPS) IN BLENDED LEARNING

Adaptive learning platforms (ALPs) tailor content delivery based on learner performance, style, and pace. Scholars highlight their potential in creating real-time personalized pathways that

improve engagement and achievement(Akintola et al., 2025; Opesemowo & Adewuyi, 2024; Paola et al., 2024; UNESCO, 2017). Examples include Knewton, DreamBox, and Smart Sparrow, which have been shown to produce statistically significant gains in mathematics and language learning. Nevertheless, challenges include high costs, infrastructure demands, and the need for strong teacher professional development to ensure effective use(Nurwahid & Ashar, 2024; Pane, 2017).

Practical Example: Quadratic Functions in an ALP

GeoGebra Exploration: Students manipulate parameters *a*, *b*, and *c* to explore the parabola's shape, direction, and intercepts.

Adaptive Module Launch: If a student struggles, the ALP provides videos or scaffolded problems; if successful, it advances them to application-level tasks (e.g., quadratic motion, optimization problems).

Dynamic Feedback & Branching: The system detects errors (e.g., discriminant misconceptions) and directs learners to remediation or enrichment.

GeoGebra Reintegration: Students create and analyze their own quadratic equations, explaining roots, vertex, and orientation. This process reflects the internalization stage of the Cycle Model (CM**)**.

3.6. DEFINING PEDAGOGICAL TRAINING FOR BLENDED LEARNING

Effective pedagogical training for blended learning (BL) is a form of professional development that empowers educators to thoughtfully orchestrate technology across physical and digital learning spaces. Such training must be underpinned by reliable institutional infrastructure, a foundational element highlighted by(Buluma & Walimbwa, 2021), who note that facilitator preparedness is contingent on access to resources like university-provided Wi-Fi. Therefore, BL training encompasses not only instructional design and pedagogical theory but also the strategic utilization of technological assets to create coherent and effective learning experiences.

4. RESEARCH METHODOLOGY

This study employed a quantitative research methodology to collect reliable, valid, and generalizable data. The primary data collection tool was a structured survey instrument consisting of 78 items off which only 34 items were included in this manuscript, adapted from validated scales in prior studies and then piloted on small sample size of 7 teachers to measure key constructs relevant to blended learning and technology integration.

4.1. PARTICIPANTS AND DATA COLLECTION INSTRUMENTS

A purposive sampling technique was used to invite teacher trainers to participate in the study via an online questionnaire and the respondents who voluntarily completed the survey filling the consent form online, representing a self-selected subset of the purposively identified population. The study was conducted among secondary school teachers in Central Ethiopia regional states. The sample included teachers and a geographically focused sampling strategy selected from Hadiya Zone, Kembata Zone, Tembaro Special Woreda, and Halaba Zone in Central region, Ethopia. A total of 53 teachers were participated, selected through purposive sampling to ensure representation across both urban and rural school contexts (inclusion and exclusion criteria were employed). Data were collected via an online survey administered through Microsoft Forms, and paper based which enabled wide access and convenience for participants.

4.2. DATA ANALYSIS

Quantitative data were analyzed using SPSS version 27, employing descriptive statistics, and regression modeling, to identify predictive factors among the measured constructs.

4.2.1. Issues of Reliability and Validity of the instruments

Table 1: Reliability Statistics and Scale Dimensions for the Research Instruments

Categorized scale/theme	**Measurement Metric / Anchor Range**	Cronbach's Alpha	N of Items	Status/Action
Knowledge Towards Technology/Blended Learning	1(Strongly disagree) to 5(Strongly Agree)	0.604	9	All 9 items were retained

Use of Interactive Assessment Tools	1(Strongly disagree) to 5(Strongly Agree)	0.640	4	All 4 items were retained
Use of AI-Enhanced Feedback Systems	1(Strongly disagree) to 5(Strongly Agree)	0.811	4	All 4 items were retained
Use of Adaptive Learning Platforms	1(Strongly disagree) to 5(Strongly Agree)	0.670	4	All 4 items were retained
Perception and Motivation	1(Strongly disagree) to 5(Strongly Agree)	0.869	3	All 3 items were retained
Google applications/ tools in Education	1(Never),to 5(Very Often)	0.857	10	All 10 items were retained

To establish the internal consistency and structural integrity of the research instrument across its various subscales, reliability analyses were performed using Cronbach's alpha coefficients based on sample execution (N = 7; see Table 1) who were not included in this main study. The evaluation demonstrated that the subscales possessed acceptable to excellent internal consistency, with alpha values ranging from .604 to .869, thereby confirming that the item clusters coherently measured their designated latent constructs. Specifically, the foundational scale measuring Knowledge Towards Technology/Blended Learning met minimum exploratory thresholds Cronbach's alpha = .604 across 9 items), while more complex operational dimensions such as the Use of AI-Enhanced Feedback Systems (Cronbach's alpha = .811) and the Google Applications/Tools in Education metric (Cronbach's alpha = .857) displayed high-tier reliability. Ultimately, the dependent variable subscale, Perception and Motivation, exhibited the highest degree of internal alignment (Cronbach's alpha = .869 across 3 items). Because all calculated coefficients safely satisfied standard psychometric benchmarks, every item across the six thematic dimensions was meticulously retained for subsequent inferential modelling, validating the questionnaire as a highly stable diagnostic tool for assessing secondary school Mathematics teachers.

Content Validity: To establish content validity, we have convened a panel of experts—typically 5 individuals with expertise from Mathematics educators (3 experts) and ICT experts (2 experts) in the University which aligned with TPACK, blended learning, AI in education, and survey methodology. These experts would review each of the 78 items for relevance, clarity, and representativeness of the target constructs. Items failing to meet these criteria were revised based on expert feedback.

5. RESULTS AND DISCUSSION

5.1. RESULTS

5.1.1. Demography of the Participant

This study purposively sampled fifty-three in-service secondary school teachers from central Ethiopia that were included in the main study by clustering schools geographically during the 2025 and 2026 academic year, selected based on their active teaching status and accessibility via email communication while teachers were trained with the program special capacity building for secondary teachers at University level and paper form for who could not get a chance for training at the University. All participants were aged 26 years or older, comprising twenty-three teachers with Bachelor's degrees (BSc) and forty with Master's degrees (MSc).

5.1.2. Analysis of technology-supported instructional tools that most predict for teacher motivation and perception

Before conducting the primary analyses, the statistical assumptions underlying multiple linear regression were rigorously evaluated to ensure the validity and reliability of the model. First, the assumption of normality was evaluated using the One-Sample Kolmogorov-Smirnov test with Lilliefors significance correction indicated in table 2.

Table2: *One-Sample Kolmogorov-Smirnov Results for Normality Testing*

		Use of Interactive Assessment Tools	Use of AI-Enhanced Feedback Systems	Use of Adaptive Learning Platforms	Perception and Motivation
N		53	53	53	53
	Mean	15.45	15.15	14.94	11.70
	SD	2.189	3.028	2.240	1.514
Test Statistic		.221	.254	.191	.371
Asymp. Sig. (2-tailed)		.000	.000	.000	.000
Monte Carlo Sig. (2-tailed)		.000	.000	.000	.000

Before running the primary analysis, the statistical assumptions for multiple linear regression were rigorously evaluated and investigated in five steps. First, the assumption of univariate normality was checked using the One-Sample Kolmogorov-Smirnov test. The results indicated that the raw data distributions for the Use of Interactive Assessment Tools ($N(53) = .221$, $p < .001$), Use of AI-Enhanced Feedback Systems ($N(53) = .254$, $p < .001$), Use of Adaptive Learning Platforms ($N(53) = .191$, $p < .001$), and the dependent variable, Perception and Motivation ($N(53) = .371$, $p < .001$), all significantly deviated from normality (see Table 2). These findings were confirmed by Monte Carlo significance tests (p= .001).Hence, data transformations were not applied because multiple linear regression is structurally robust to non-normal raw independent and dependent variables, provided the model's standardized residuals are normally distributed and homoscedastic see figure 2 and supported by (Tabachnick & Fidell, 2013). Second, multicollinearity among the independent variables was evaluated using two complementary diagnostic metrics: Variance Inflation Factors (VIF) and an eigenvalue-based decomposition analysis indicated in Table 3.

Table 3: Multiple Linear Regression Predictors of Perception and Motivation

Model		Unstandardized Coefficients		Standardized Coefficients			Collinearity Statistics	
		B	Std. Error	Beta	t	Sig.	Tolerance	VIF
1	(Constant)	4.372	1.212		3.608	.001		
	Use of Interactive Assessment Tools	-.101	.070	-.146	-1.445	**.155**	.842	1.188
	Use of AI-Enhanced Feedback Systems	.131	.050	.261	2.641	.011	.872	1.147
	Use of Adaptive Learning Platforms	.462	.070	.683	6.611	.000	.800	1.249

As shown in Table 3, all VIF values were below the standard threshold of 5.0 (ranging from 1.147 to 1.249), and all Tolerance statistics were safely above 0.10. To provide a deeper look, a collinearity diagnostics breakdown was executed (see Table 4). The highest obtained Condition Index was 20.689, which sits safely below the critical threshold of 30.0 that typically indicates severe multicollinearity issues. While the index of 20.689 hints at a mild, expected variance overlap

among the modern digital learning subscales, the combined VIF and Condition Index profiles demonstrate that the predictors are sufficiently distinct to yield stable regression coefficients. Third, the assumptions of linearity and homoscedasticity were visually assessed using a scatterplot mapping the regression standardized residuals against the regression standardized predicted values indicated in Figure 2 and indicated that the random distribution of the data points across the plot canvas indicates that the regression model satisfactorily meets the assumptions of linearity and homoscedasticity, with constant error variance across all predicted levels. At this stage, we are happy and can apply Multiple regression analysis and arrive the finding of the study. The residuals were distributed randomly in a uniform cloud across the plot without any noticeable funneling, geometric patterns, or structural curvature. Finally, independence of errors was verified via the Durbin-Watson statistic (2.011) indicated in table 5, which falls near the ideal value of 2.0, confirming no autocorrelation issues. All underlying mathematical assumptions were met.

Table 4 *Collinearity Diagnostics for the Regression Model Predictors*

				Variance Proportions			
Model	Dimension	Eigenvalue	Condition Index	(Constant)	Use of Interactive Assessment Tools	Use of AI-Enhanced Feedback Systems	Use of Adaptive Learning Platforms
1	1	3.953	1.000	.00	.00	.00	.00
	2	.025	12.545	.03	.09	.97	.04
	3	.013	17.542	.02	.43	.01	.85
	4	.009	20.689	.95	.48	.01	.11

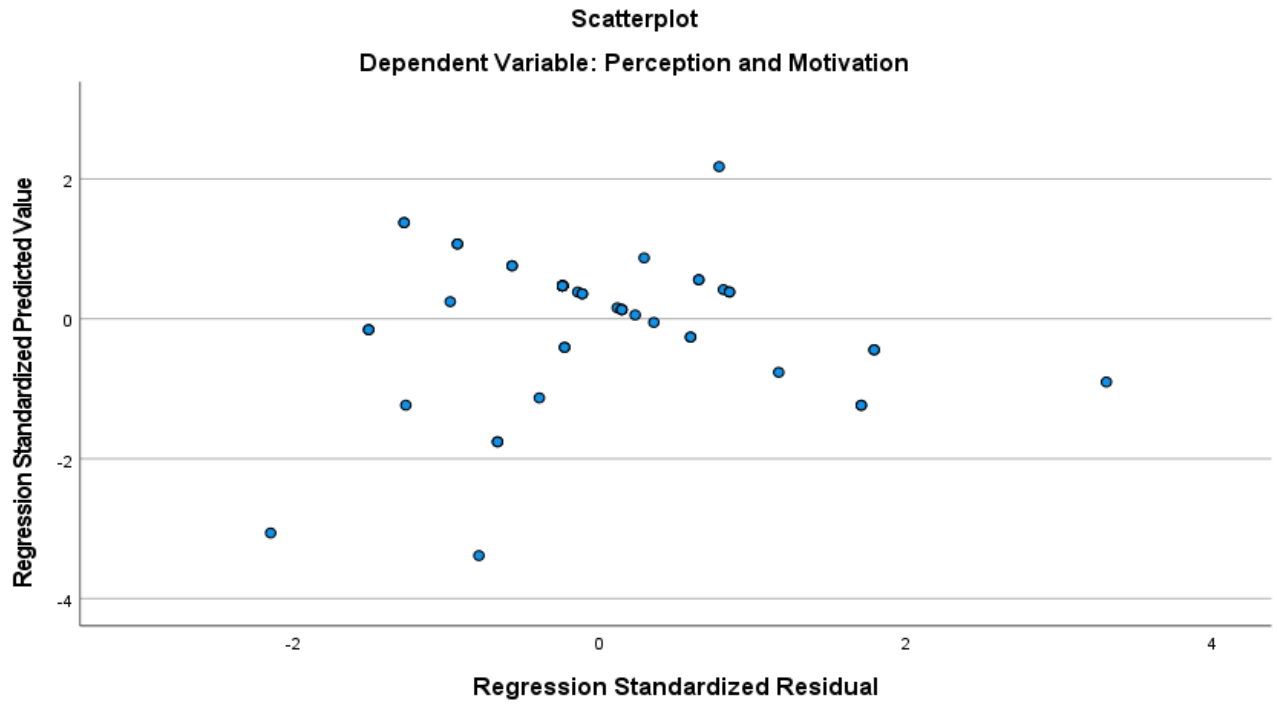


Figure 2 *Scatterplot of Regression Standardized Residuals Against Regression Standardized Predicted Values for the Model Predicting Perception and Motivation*

Table 5 *Regression Model Summary for Predictors of Perception and Motivation*

Model	R	R^2	Adjusted R^2	Std. Error of the Estimate	R^2 Change	F Change	df1	df2	Sig. F Change	Durbin-Watson
1	.762	.581	.555	1.009	.581	22.648	3	49	.000	2.011

A multiple linear regression analysis was conducted with Use of Interactive Assessment Tools, Use of AI-Enhanced Feedback Systems, and Use of Adaptive Learning Platforms as the independent variables, and Perception and Motivation as the dependent variable. The overall regression model was found to be highly statistically significant, F (3, 49) = 22.648, p < .001. The combination of these three digital assessment predictors explained **58.1** of the total variance in participants' overall Perception and Motivation (R^2 = .581, Adjusted R^2 = .555). This represents a strong collective effect size.

In general, evaluating the individual contributions of each predictor revealed distinct behavioral influences across the subscales. **Use of Adaptive Learning Platforms** emerged as the most powerful unique positive contributor to the model (β = .683, t(49) = 6.611, p < .001). Specifically, holding all other variables constant, every one-unit increase in the use of adaptive learning platforms predicted a 0.462-unit increase in participants' overall Perception and Motivation scores (B = 0.462, SE = 0.070). **Use of AI-Enhanced Feedback Systems** was also a statistically significant positive predictor (β = .261, t(49) = 2.641, p = .011), where a one-unit increase in feedback utilization corresponded to a 0.131-unit increase in the outcome metric (B = 0.131, SE = 0.050). Conversely, when controlling for the presence of adaptive and feedback systems, the **Use of Interactive Assessment Tools** did not yield a statistically significant unique contribution to the model β = -0.146, t(49) = -1.445, p = .155, B = -0.101, SE = 0.070).

5.1.2. Analysis of Teachers knowledge regarding technology usage and blended learning

To evaluate the baseline level of teachers' knowledge and practices regarding technology usage and blended learning frameworks, item-level descriptive statistics were analyzed (see Table X).

Table 6 Descriptive *Statistics for Teachers' Technological Knowledge(Blended) and Practices*

	N	Mean	Std. Deviation	Skewness		Kurtosis	
					Std. Error		Std. Error
I have used technology in my learning and teaching process	53	3.43	1.029	-.532	.327	-.805	.644
I have seen other teachers use technology in the classroom	53	3.62	.925	-.830	.327	.345	.644
I know about some exemplary materials of using technology	53	3.64	.901	-1.017	.327	.697	.644
I always have downloaded the mathematical software from the internet for my personal study	53	3.85	.864	-1.373	.327	2.247	.644
I know the Meaning of the term Blended learning	53	3.72	.968	-.713	.327	-.418	.644

I know Dynamics software GeoGebra	53	3.85	.864	-.814	.327	.341	.644
I know the definition of blended learning form my own experiences	53	3.55	1.030	-.516	.327	-1.014	.644
Blended learning is a process of solely using online teaching and learning mode	53	3.53	1.103	-.298	.327	-.928	.644
Blended learning is a mixture of using both face to face and online approaches	53	3.75	1.017	-.847	.327	.076	.644
Aggregated mean		3.66					

Overall, the participants displayed a highly positive orientation and strong foundational literacy toward technological integration. Teachers exhibited their highest levels of confidence in self-directed digital behaviors and specific software familiarity, reporting high agreement both for actively downloading mathematical software from the internet (M = 3.85, SD = 0.864) and for knowing how to navigate dynamics software such as GeoGebra (M = 3.85, SD = 0.864).

Furthermore, conceptual awareness was robust, as teachers firmly understood the definitions underlying blended learning applications (M = 3.72, SD = 0.968). However, a slight nuance emerged when comparing theoretical knowledge to active application; while teachers frequently observed peers integrating digital elements (M = 3.62, SD = 0.925), their own active use of technology within the learning and teaching process yielded the lowest relative mean baseline (M = 3.43, SD = 1.029). Across all items, negative skewness values indicated a consistent, sample-wide consensus prioritizing high technological readiness and familiarity over technophobia or instructional detachment.

5.1.3. Analysis of Teachers use Google Application in Education

To evaluate the specific behavioral patterns and deployment frequencies of educational technology applications, item-level descriptive statistics, frequencies, and percentage distributions were examined (see Table 7). Overall, the sample yielded an aggregated mean score of 2.896, positioning the cohort's baseline operational technology usage slightly below the scale's neutral midpoint. This moderate average is structurally driven by a uniform clustering effect across the distribution; for every single application evaluated, the modal response category was 'Sometimes,'

capturing between 45.3% and 56.6% of the total sample. This concentration indicates a widespread, occasional utility model across the faculty, rather than a polarized environment split between expert adopters and total non-adopters. A granular assessment of the highest frequency metrics revealed that communication and media consumption serve as the primary gateways for technology deployment. Utilizing Gmail for educational correspondence (M = 3.19, SE = .121) and leveraging YouTube to source instructional videos (M = 3.08, SE = .129) stood out as the only applications to exceed the neutral value, backed by a combined 'Very Often' and 'Often' retention rate of 30.1% and 28.3%, respectively. Conversely, advanced creation and evaluation utilities occupied the lowest operational tiers. Notably, for both Google Forms (M = 2.77, SE = .113) and Google Slides (M = 2.74, SE = .115), exactly 0% of the participants reported using them 'Very Often,' with a substantial proportion relegating their use to 'Rarely' or 'Never' (28.3% for Forms and 32.0% for Slides). This structural drop-off implies that while teachers routinely engage with passive communication tools, active creation and digital assessment design continue to face implementation friction.

Table 7: *Frequencies, Percentages, and Mean Scores for Specific Educational Technology Tool Utilization*

Digital Tool Item / Application	N	Mean	SE of Mean	Very often	Often	Sometimes	Rarely	**Never**
Chatbots in Education integrated with Google tools	53	2.85	.146	1(1.9%)	13(24.5%)	26(49.1%)	3(5.7%)	10(18.9%)
Google Docs for text editing and collaboration	53	2.96	.142	2(3.8%)	14(26.4%)	24(45.3%)	6(11.3%)	7(13.2%)
Google Classroom for course/assignment management	53	2.81	.135	1(1.9%)	11(20.8%)	25(47.2%)	9(17.0%)	7(13.2%)
Google Drive for file storage and sharing	53	2.94	.125	2(3.8%)	11(20.8)	25(47.2%)	12(22.6%)	3(5.7%)
Gmail for educational email communication	53	3.19	.121	4(7.5)	12(22.6%)	29(54.7%)	6(11.3%)	2(3.8%)
Quizizz for gamified online quizzes	53	2.79	.151	2(3.8%)	11(20.8)	24(45.3%)	6(11.3%)	10(18.9%)
YouTube to access or share educational videos	53	3.08	.129	3(5.7%)	12(22.6%)	28(52.8%)	6(11.3%)	4(7.5%)
Google Sheets for organizing and analyzing data	53	2.83	.134	2(3.8%)	8(15.1%)	29(54.7%)	7(13.2%)	7(13.2%)

Google Slides for making educational presentations	53	2.74	.115	0(0%)	8(15.1%)	28(52.8%)	12(22.6%)	5(9.4%)
Google Forms for surveys, quizzes, and feedback	53	2.77	.113	0(0%)	8(15.1%)	30(56.6%)	10(18.9%)	5(9.4%)
Aggregated mean			**2.896**					

Summary of Findings

The study demonstrates a clear "pedagogical paradox" within Ethiopian secondary education, where teachers possess high conceptual and cultural readiness to accept AI and blended learning but face operational bottlenecks during practical execution.

- **For RQ1 (Conceptualization & Implementation of Training):** Descriptive baselines show that while teachers actively understand blended concepts (M = 3.72) and GeoGebra software (M = 3.85), their actual instructional deployment of technology yielded the lowest relative mean baseline (M = 3.43, SD = 1.029). Because advanced creation modules like Google Forms or Google Slides suffer from a 0% high-frequency ("Very Often") usage rate, pedagogical training cannot remain theoretical; instead, professional development must be implemented as hands-on, subject-specific workshops focused directly on active digital content curation and interactive platform management.
- **For RQ2 (Predictors of Teacher Motivation**): The ordinary least squares multiple linear regression modeling proved highly significant ($F(3, 49) = 22.648$, $p < .001$, $R^2 = 0.581$), revealing that high-agency personalized tools are the definitive keys to unlocking teacher engagement. Specifically, the Use of Adaptive Learning Platforms emerged as the single strongest unique positive predictor ($\beta = 0.683$, $t = 6.611$, $p < .001$), followed closely by the Use of AI-Enhanced Feedback Systems $\beta = 0.261$, $t = 2.641$, $p = .011$), while the Use of Interactive Assessment Tools demonstrated no statistically significant unique effect $\beta = -0.146$, $p = .155$).
- **For RQ3 (Teacher Readiness to Accept Innovations**): Skewness values confirm that teachers are culturally ready and harbor no intrinsic technophobia, frequently downloading software (M = 3.85) and observing digital peers (M = 3.62). However, their practical workspace tool utilization sits below the neutral midpoint (aggregated M = 2.896) because the participant's deployment clusters heavily around passive workflows such as

educational correspondence via Gmail (M = 3.19) and sourcing videos on YouTube (M = 3.08) revealing that teachers are conceptually ready to accept these tools but operationally bottlenecked when moving toward active, high-frequency digital execution**.**

5.2. DISCUSSION

The empirical findings of this study offer a nuanced perspective on the ongoing digital transformation within sub-Saharan Africa particularly Ethiopia, challenging the techno-optimistic assumption that the mere introduction of digital applications linearly translates into enhanced educator engagement. The structural regression model demonstrated that the selected technological predictors accounted for only a limited proportion of variance in teacher perception and motivation (R^2 = 0.203, p > 0.05), signaling that meaningful pedagogical integration operates within a complex ecosystem of cultural, systemic, and infrastructural variables.

5.2.1. The paradox of technology access versus perception and motivation

The lack of a statistically significant positive relationship between interactive assessment tools and teacher motivation contrasts sharply with Western-centric educational literature, yet aligns profoundly with the systemic realities documented by local and regional scholars. During our baseline training sessions in summer 2024, significant digital literacy gaps were observed, with several educators struggling with foundational operations such as navigating basic hardware components or authenticating platform profiles. This observational evidence is supported by **Bedada (2021)**, who underscores through the Instructional Technology-Oriented Cycle Model (ITOCM) that introducing digital tools without establishing a stable, supportive baseline environment induces cognitive overload and systemic friction rather than pedagogical motivation.

When teachers lack basic technological fluency, advanced platforms like GeoGebra or gamified assessment modules switch from being instructional aids to operational burdens. This systemic disconnect is further articulated by **Machaba and Bedada (2022)**, who emphasize that geographic isolation and stark resource disparities between rural and urban institutions significantly exacerbate the digital divide. In regional zones like Hadiya, Kembata, and Halaba, inconsistent broadband access and rolling electricity blackouts mean that implementing real-time interactive assessments creates instructional anxiety rather than motivating teachers.

5.2.2. Theoretical Intersections and Systemic Contradictions

When analyzed through the lens of Activity Theory, the instructional ecosystem reveals a clear contradiction between the technological *tools* deployed (e.g., Google Classroom, adaptive learning modules) and the structural *rules* and *community* configurations governing Ethiopian secondary education. The national mandates of the Digital Skills Country Action Plan (DSCAP 2020–2030) and the "Digital Ethiopia 2025" initiatives outline an ideal framework for digitized human capital development. However, as **Gemechu et al. (2017)** noted, while digital systems have found functional utility in high-level university administrative tasks (e.g., dormitory allocation and registration tracking), their deep assimilation into core classroom pedagogy remains remarkably limited. This historical lag confirms our finding that macro-level policy visions are frequently decoupled from the micro-level operational readiness of the classroom teacher.

Furthermore, the weak positive trajectory observed for AI-enhanced feedback systems and Adaptive Learning Platforms (ALPs) implies that personalized educational frameworks are recognized as theoretically valuable, but remain structurally unsupported. For an Intelligent Tutoring System (ITS) to successfully manage dynamic difficulty adjustments, the underlying digital architecture must be consistently active. As argued by **Buluma and Walimbwa (2021)**, teacher readiness and facilitator preparedness are directly constrained by institutional infrastructure, such as reliable, university- or school-provided Wi-Fi networks. Without these foundational affordances, the core tenets of the Technological Pedagogical Content Knowledge (TPACK) framework fail to solidify; teachers cannot merge content knowledge with technological application if the hardware layer remains volatile.

5.2.3. Socio-Emotional and Pedagogical Competencies

The shifting landscape of 21st-century education demands that secondary school educators look past traditional lecturing to cultivate sophisticated socio-emotional, technical, and managerial skills. **Sidelil et al. (2023)** emphasize that an educator's digital competence is fundamentally linked to their broader professional development and institutional transformation. When teachers are forced to navigate complex AI applications—such as automated essay scoring or responsive

mathematics applets without ongoing, context-sensitive training, their perceived self-efficacy drops. This drop directly undermines their instructional motivation.

The empirical reality of the Ethiopian classroom demonstrates that sustainable education cannot be achieved through top-down technological deployment. To prevent student disengagement in core areas like mathematics, and to build sustainable learning pipelines, digital platforms must serve as an adaptive layer that supports the teacher rather than replacing or overwhelming them. Successful digital transformation requires a balanced strategy where systemic investments in hardware are matched by localized, iterative pedagogical training.

When synthesizing the descriptive baseline of participants habits with the primary regression model, a critical pedagogical paradox emerges regarding digital implementation. The regression analysis established that advanced, high-agency structural systems namely, the Use of Adaptive Learning Platforms (β = .683, p < .001) and AI-Enhanced Feedback Systems (β = .261, p = .011) serve as the premier drivers of student Perception and Motivation.

However, the item-level frequency data indicates that teachers' current technological deployment remains heavily restricted to passive utility frameworks and basic communication workflows. While routine administrative correspondence via Gmail (M = 3.19) and video consumption on YouTube (M = 3.08) are firmly established, specialized content-generation and assessment utilities like Google Forms (M = 2.77) and Google Slides (M = 2.74) suffer from an absolute absence of high-frequency (Very Often') use.

This misalignment suggests a structural gap in teacher readiness: the digital interventions proved to be the most vital for stimulating student engagement are the exact archetypes that demand active, complex digital construction—a domain where teachers currently cluster at occasional or intermediate deployment. Consequently, maximizing student motivational outcomes requires moving professional development beyond generic technical literacy and explicitly training educators in active digital content curation, algorithmic feedback mechanisms, and adaptive platform management.

Modern educational technology applications, ranging from AI-powered chatbots to the integrated Google Workspace suite, have fundamentally transformed the landscape of learner engagement

and instructional delivery. AI-driven chatbots serve as conversational agents that simulate human interaction, enhancing motivation and self-regulated learning by providing real-time support and personalized assessment feedback (Winkler & Söllner, 2018; Pérez-Marín, 2021). Within the Google ecosystem, collaborative platforms such as Google Docs and Google Drive promote constructivist learning through co-constructed knowledge and seamless file sharing, while Google Classroom streamlines administrative tasks like grading and communication in blended learning environments. Specialized tools like Google Sheets facilitate data analysis and mathematical collaboration, Google Slides enhances presentation and design skills, and Google Forms provides efficient, real-time formative assessment through automated grading. Furthermore, communication tools like Gmail support formal asynchronous dialogue, while YouTube encourages multimodal learning and conceptual understanding through high-quality instructional videos, collectively fostering an accessible, interactive, and highly collaborative educational experience.

The integration of AI in secondary mathematics education through blended learning holds great promise for Ethiopia. It offers new pathways for enhancing instructional delivery, fostering student engagement, and supporting teachers in their professional roles. However, its successful implementation demands a careful balance between leveraging technological affordances and preserving core pedagogical principles. This balance ensures that technology complements rather than displaces the human dimensions of teaching, such as mentorship, dialogic learning, and critical thinking.

5.3. FUTURE RESEARCH DIRECTIONS

Future research should utilize broader, more diverse samples and non-parametric alternatives where necessary to more accurately map the complex relationship between digital affordances and the pedagogical needs of teachers. Future studies should employ mixed-methods approaches to integrate quantitative analyses with qualitative insights into teachers' perceptions, challenges, and pedagogical strategies. Additionally, longitudinal research could illuminate how teachers' motivation evolves over time with sustained exposure to blended learning and AI-enhanced feedback systems. Finally, system-level studies that investigate institutional support, curriculum

alignment, and leadership roles would offer valuable insights into the broader ecosystem of digital transformation in education (Bulto et al., 2025; Sandoval-Benavides & López-Ornelas, 2025).

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Declarations

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Data Availability

The datasets generated and/or analyzed during the current study are available from the corresponding author on reasonable request.

Conflict of Interest

The authors declare that they have no conflict of interest.

Ethical Approval

This study was exempted from formal ethical approval by the Ethics Committee for Research Involving Human Subjects from Wachemo University institutional review board with Ref:WCU-IRB/0067/25. Participants were informed of the study's purpose, procedures, and their right to withdraw at any time without penalty at both pilot study and main study. The study involved anonymous survey data and did not collect sensitive personal information. Informed consent was obtained from all participants. All procedures involving human participants were performed in

accordance with relevant institutional and national guidelines and regulations, and with the principles of the Declaration of Helsinki. Confidentiality was ensured by assigning pseudonyms and removing identifying information from the data. Data were stored securely and accessed only by the research teams.

Consent to Participate

Participation in the study was voluntary and anonymous. Informed consent was obtained from all participants prior to their inclusion in the study.

Consent to Publish

Not Applicable.

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