



Integrating Advanced ICT Tools for Promoting Student Engagement and Academic Performance in Malian Higher Education

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ABSTRACT

This work shows that the use of ICT in Malian Higher Education has significantly improved both student engagement and academic performance, with increases in the average GPA, graduation rate, and digital literacy. E-learning platforms, mobile apps, AI, and virtual reality offer transformative potential, but infrastructure gaps, inadequate faculty training, and pedagogical resistance remain barriers. Successful ICT integration requires more than technology deployment; it demands strong leadership, sustained funding, flexible teaching practices, and contextually relevant, mobile-friendly approaches. Private colleges are outperforming public institutions, revealing systemic inequalities that need policy intervention. To bridge the digital divide, efforts should focus on improving infrastructure, expanding digital skills training for community leaders, and revamping curricula to include digital literacy. Ultimately, unlocking ICT's full educational potential depends on multi-stakeholder collaboration among policymakers, educators, tech providers, and students to build inclusive, sustainable learning ecosystems. Such initiatives will prepare Malian graduates for participation in the global digital economy.

Keywords

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Introduction

Tertiary institutions in Mali encounter many challenges such as a lack of infrastructure, absence of recent technology, and minimal integration of ICT tools, leading to a lackadaisical approach in students' participation and performance [1]–[2]. Although the government has been making efforts to increase access to higher education, the sector is still constrained by conventional teaching approaches and a lack of digital resources that have implications for educational quality and student performance [3].

The use of powerful ICT tools offers an encouraging response to these challenges, creating new forms of interactive learning and enhancing academic achievement; however, such uses are slow to develop because of both infrastructure and institutional barriers [4]. These issues are important if Mali wants to move towards regularization of its higher education system and prepare students for the needs of the information age [5]. The use of Information and Communication Technologies (ICT) in higher education has been a key strategy to increase student involvement and academic performance, particularly in developing countries such as Mali.

Recent studies highlight that the use of innovative ICT tools (for example, e-learning platforms, mobile applications, and interactive multimedia) can strongly promote active learning, enhance access to education, and narrow educational disparities [6]. While universities in Mali are striving to adapt to the digital age, appropriate use of these technologies shows potential in changing teaching methodologies and advocating for inclusive quality education. This development coincides with global focus on the digital turn of educational growth in the 21st century [7].

As advanced ICT tools, including e-learning platforms, mobile applications, artificial intelligence (AI), and virtual/augmented reality, are increasingly being adopted in higher education in Mali, they provide new opportunities to enhance student engagement and academic achievement. These promote personalized learning and open access to educational materials, support interactive pedagogies, which are important in the context where Malian infrastructure often makes traditional education impossible [8]. While trying to modernize for the digital era, higher education institutions in the region can take a cue from these cutting-edge ICT tools as an effective approach to improve learning and balance the lopsidedness of educational opportunities across Nigeria.

A. Problem Statement

The mainstreaming of Advanced ICT in Malian universities is a serious issue for the orientation of pedagogic practices with modern technological achievements. However, despite

the growing trend of use of digital resources, several Malian universities are confronted with barriers such as lack of infrastructure, inadequate training for teachers, or even insufficient access to up-to-date ICT tools that are up-to-date which affect policy-making and decisions on adoption. That gap is a significant barrier to enhancing student engagement and performance, with the quality of post-secondary education suffering as a result. Without strong policies informed by current technology trends, Mali has the potential to lag in supplying such a competitive learning environment for today's students [9].

Computer Classroom Integration of advanced ICT tools into their processes to optimize experiences in teaching and learning is crucial in promoting students' activity and academic performance at the university level in Mali. Recent studies show that new digital tools, such as interactive platforms, virtual labs, and e-learning systems, have a significantly higher impact on students' motivation in personalized learning. But the absence of cohesive strategies and decision-making mechanisms that enable the adoption of these technologies degrades their possible benefits. This can only be achieved through evidence-based policy development, which will explore issues related to infrastructure, pedagogy, and socio-economic impact; and ultimately allow Mali to harness ICT innovations in ways that would foster improved educational results [10].

B. Significance of the Study

The relevance of this research is that it has the potential to revolutionize tertiary education in Mali through the use of state-of-the-art ICT tools with a view to enhancing students' involvement and academic achievement. Given Mali's continuing struggles in terms of educational quality and accessibility, new ICTs may be used to create better connected and more engaging learning environments, leading to higher student motivation, participation, and retention. Recommendations of the findings of this study are crucial for policymakers, educators, and technology designers to develop effective e-learning interventions that meet the educational goals of Mali and, in turn, foster its socio-economic development and digital revolution.

C. Research Objectives

- To assess the implementation of ICT in Malian higher education
- To investigate the effects of innovative ICT tools on student engagement and learning performance

D. Research Questions

- How pervasive is ICT in Malian HEIs and what underlies the decision to adopt or not?

- What are the effects of advanced ICT tools on student engagement and academic achievement in Malian higher education, and what best practices can be described to increase their effectiveness?

Theoretical Frameworks

A. Diffusion of Innovations Theory

The diffusion of innovations theory, constructed by Everett Rogers et al. [11] describes how new technologies are assimilated in educational institutions, focusing on the way in which an innovation is communicated and adopted over time among members of a social system. Under the framework of implementing advanced ICT tools for improving student engagement and academic performance in higher education in Mali, it is emphasized that factors such as communication channels, what the innovation can offer to ease teaching or learning (perceived benefits /value), and social influence on decision-making by change agents are key to adoption. Recognizing such dynamics provides institutions with insights on how to implement OE strategically and foster a culture of innovation among faculty and students toward the acceleration of OE adoption and improvements in student learning [11].

B. Engagement Theory

Developed by Everett Rachmad [12], the Diffusion of Innovations Theory highlights how new technologies and practices are distributed throughout a society. For the introduction of advanced ICT tools to enhance collaborative and interactive learning in higher education in Mali, this theory draws attention to the role of social networks, communication channels, and perceived benefits in shaping adoption behavior among both students and faculty. The successful adoption of these innovative ICT practices could strongly contribute to higher levels of student interaction and learning through peer exchange and active participation, which can, in turn, increase the rapid acceptance and continued use of technology within the educational context [12].

C. Technology Acceptance Model (TAM)

The Technology Acceptance Model (TAM) affords an important explanatory framework in order to explain the acceptance and use of advanced ICT tools by students in higher education, especially in situations such as Mali where the digital revolution is underway. This theory posits that perceived usefulness and perceived ease of use are key antecedents to the students' intention to adopt new applications, resulting in engagement and academic performance [13]. The research has expanded TAM to investigate ICT utilization in developing countries, with students' positive perceptions significantly impacting their usage and academic achievement, particularly when more advanced devices are easy to use and congruent [14]. The use of TAM in Mali highlights the

necessity for accessible and relevant digital tools that increase acceptance and ultimately enhance educational experiences.

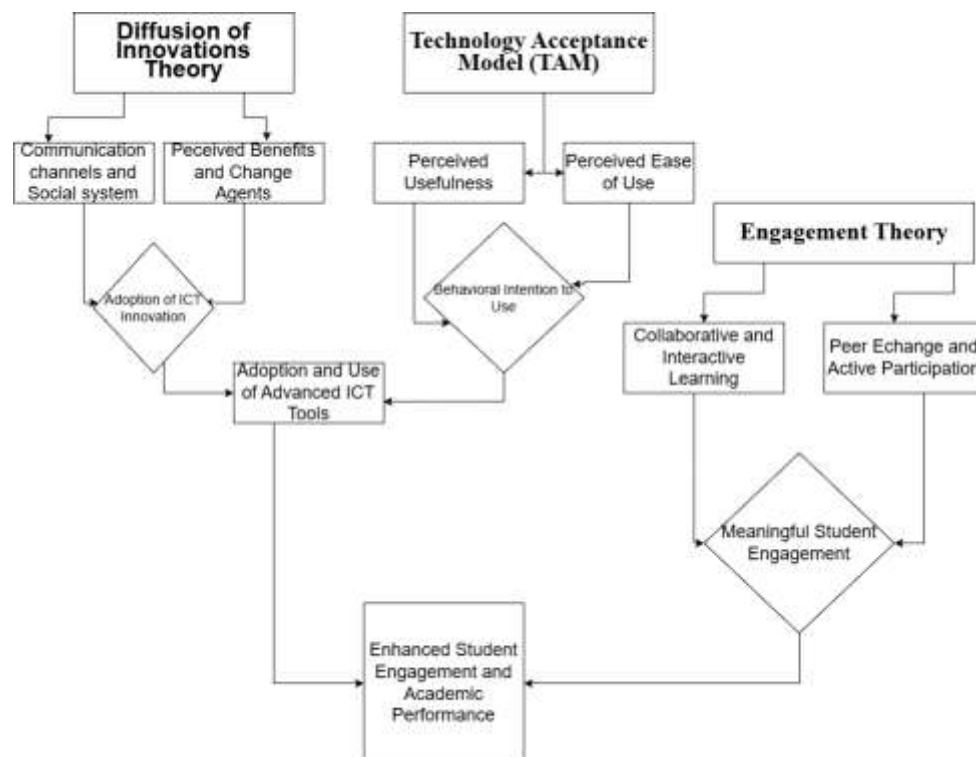


Fig. 1. Theoretical Framework Vision

This framework combines three theories: Diffusion of Innovations (how ICT spreads via social systems and benefits), TAM (user motivation through usefulness and ease), and Engagement Theory (interactive, participative learning). These streams converge, showing how adoption and engagement boost student performance through causal pathways.

Literature Review

A. Global Context

Several cases have shown that the successful integration of ICT in higher education across the globe has brought about significant positive effects on student engagement and performance. For example, e-learning platforms and mobile learning apps in South Korea have contributed to higher student engagement and academic performance [15]. Conversely, in the United States, the merger of LMS and collaborative digital tools has strengthened active learning environments with more desirable student retention rates and satisfaction [16].

These instances represent the potential of strategic incorporation of ICT tools in reversing conventional pedagogies with more interactive and personalized learning experiences that lead to increased engagement and better scholastic achievements. These international benchmarks

serve as good examples for Mali, and underline the advantage of introducing high-level ICT tools in a higher education system to increase student engagement rates and achievement.

B. Regional Context

The literature on ICT use in West Africa, which also includes studies conducted in Mali, reflects substantial advances as well as recurring hurdles. In Mali, they have faced challenges in integrating advanced ICT tools in higher education, due to a lack of infrastructure, limited connection to reliable internet, and inadequate technology equipment [17]. Moreover, a lack of skilled staff and faculty use of media also imposes limitations on its successful application [18].

There are also gaping holes in policy, the inconsistent application of the national vision, and a lack of investment in ICT development within education, which hinder sustainable school integration and scale-up [18]. These policy and infrastructural problems mirror more general regional concerns in West Africa where disparities in technology provision and resource distribution continue to shape the outcomes of ICT-based education reforms [19]. In short, there's an urgent need to redress these hurdles in order to utilize ICTs to enhance student involvement and academic quality throughout Mali's tertiary education sector.

C. Types of Advanced ICT Tools

1. E-learning platforms and Mobile learning apps

Recent research underscores the major part that advanced ICT solutions such as e-learning and mobile learning applications play in shaping today's higher education for more efficient student engagement and better academic achievement. Furthermore, e-learning platforms such as Moodle and Blackboard provide interactive tools, customized learning paths, and asynchronous communication that can encourage an individualized approach to learning with the possibility of dynamism [20]. In the same vein, learning apps support anytime, anywhere access to educational content, promoting continuity of engagement and self-learning by students [21].

As an embedded technology in the context of Malian higher education, these have demonstrated quite promising results in terms of enhancing student motivation and performance, especially in environments with less available traditional infrastructure [21]. In summary, the targeted application of these state-of-the-art ICT devices has the potential to markedly improve educational experiences and outcomes in surrounding higher learning institutions in Mali.

2. AI-based systems for tutoring in Virtual and augmented reality

The latest developments in ICT, including AI-supported tutoring systems and Virtual/augmented reality (VR/AR), have produced very promising results so far to promote student interest and performance at the higher education level. Personalized learning

environments based on AI tutor systems would themselves adjust to individual student needs, which could increase understanding and interest [22]. On the other hand, VR/AR technologies provide students with more immersive learning environments that enhance interactivity and experiential learning, which are essential to student engagement and retention of knowledge [23].

These are being used more and more in higher education institutions around the world, even in contexts such as Mali on the African continent, where their use could respond to capacity and pedagogical challenges [20]. While higher education institutions are looking for innovative ways to achieve learning outcomes, the use of advanced ICT such as AI tutoring and VR/AR can offer promising solutions for transforming education experiences and promoting academic success in Mali.

D. Impact on Student Engagement and Achievement

1. Increased participation and motivation

Recent research has found that the use of sophisticated ICT tools in higher education has a positive effect on participation and motivation levels for the students while achieving better academic results. For instance, Mali [24] points out that interactive digital platforms enable active learning and engagement among students in Mali, which are associated with above-average performance. Any technology aid not only increases access but also provokes intrinsic motivation and becomes a richer learning environment. This is consistent with international trends that have been highlighting the role of ICT in education for addressing challenges related to engagement, particularly in developing contexts such as Mali [24].

2. Better Understanding and Knowledge Retention

In higher education, combining advanced ICT tools in the teaching approach is proven to offer a promising contribution for enhancing students' understanding and memory of learned materials, leading to improved performance in academia. Recent research suggests that digital tools, interactive simulations, and m-learning applications promote active participation and deeper understanding of difficult-to-learn concepts [25]. In Mali specifically, recent research emphasized that by using ICT tools to overcome traditional educational challenges, learning becomes more accessible and interactive, which eventually contributes to better academic achievements [26]. These results highlight the need to harness technology as a tool for changing higher education and for achieving long-lasting gains in student learning.

3. Academic achievement metrics

The latest research evidence shows that using high ICT in higher education has positive effects on the students' level of involvement as well as academic achievement in Mali.

According to [27], using digital platforms and interactive technology has increased the motivation of students and improved their learning outcomes, which is shown in higher academic achievement performance characteristics such as course completion rates and exam scores. These outcomes are in line with worldwide patterns emphasizing the importance of ICT to provide active learning environments, especially in developing countries, as technological inclusion connects the educational gap [28]. Reported use of advanced ICT tools seems quite promising for academic performance in Malian higher education environments.

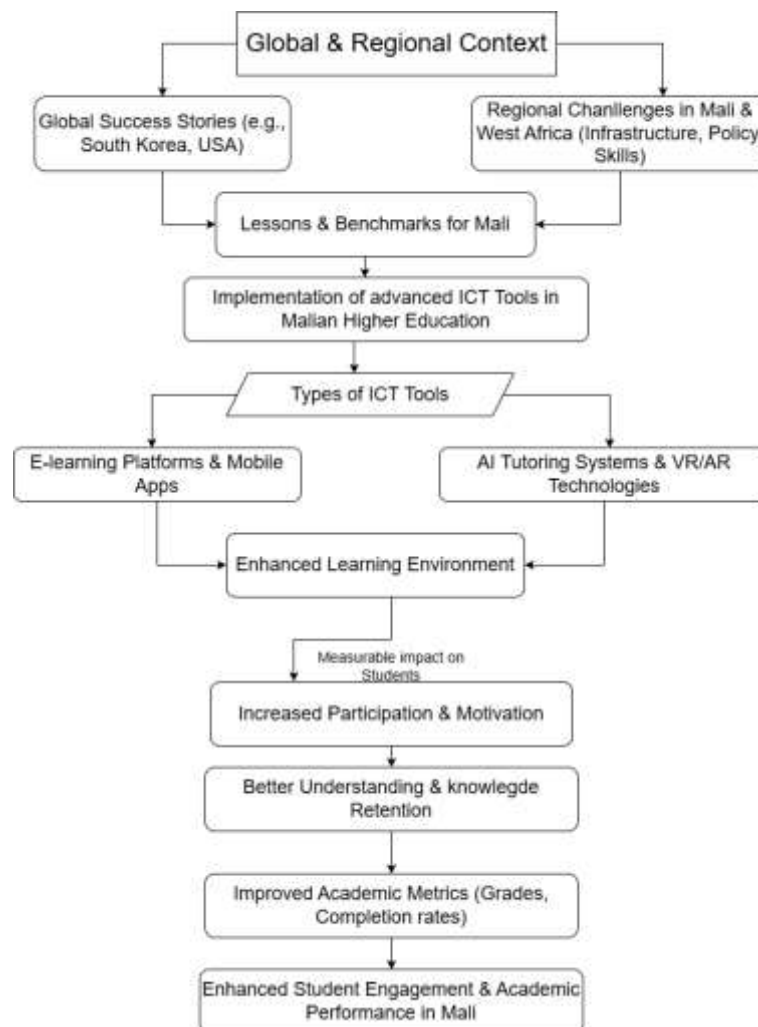


Fig. 2. This diagram illustrates the logical flow of our literature review

The flowchart outlines how adopting advanced ICT in Malian higher education—based on global successes and regional challenges—leads to deploying tools like e-learning, AI, and VR, which improve student engagement, understanding, and academic outcomes.

Methods

A. Research Design

Using Mixed-Methods, this study investigated the effect of highly sophisticated ICT tools on student engagement and their academic achievement in Malian higher education. It disaggregated data from surveys, interviews, and observations for each of these; it re-aggregated the results to determine effects on participation, learning, and success as perceived by students, faculty, and ICT facilitators across institutions.

B. Sampling

1. Techniques

A stratified random sample instrument was designed to examine the extent of advanced ICT tools and their influence on student engagement and academic performance at the Malian university level. Universities were categorized by region and type to ensure a variety of perspectives; choices were made from the regions proportionally. This strategy not only enhances the validity of findings, but also facilitates an in-depth understanding of ICT's role throughout a range of organizations in Mali.

2. Populations

Higher education faculty and administrators in Bamako, Mali will be the focus of this research, as well as students in Mali with respect to their experiences using sophisticated ICT technologies that raise student involvement levels and positively impact academic performance at Malian universities.

3. Sample Size

In each of the 10 Malian higher education institutions, 10 faculty members were randomly chosen to participate in the study. They were owed some of faculty members and ranged in levels of teaching expertise and disciplines. A further 150 students from the same universities were recruited to provide a more holistic overview of the student population, including diverse programs, years of study, and backgrounds. An additional ten university administrators participated to offer administrative views and perceptions of the use of advanced ICT for student engagement and academic success.

C. Data Collection

1. Surveys

The research instrument was a survey focused on students, faculty members, policy makers, as well as partners in the community to determine the potential for advanced ICTs to enhance student engagement and academic success at Malian institutions of higher education.

With a mixed-method methodology and stratified sampling strategy, the study investigated digital access, literacy, infrastructure perceptions, and policy support. Data analysis sought to identify major patterns with implications for successful integration of ICT and for optimizing learning.

2. Interviews

A series of semi-structured interviews with key players in the field of higher education in Mali were conducted to investigate how and why staff currently use ICT tools to improve student engagement and other academic outcomes. Lessons learned provided recommendations for more effectively embedding advanced ICT-based solutions to improve learning.

3. Document Analysis

The data collection was based on the policies and documents to see how Malian universities are leveraging advanced ICT tools to promote students' performance and retention. The authors employed a method of content analysis to examine strategies, initiatives, and gaps associated with ICT uptake, as well as learning equity through its use.

E. Data Analysis

1. Quantitative data

The research measured student-level data for enrollment, graduation rates, student engagement, and academic outcomes in Malian universities with surveys and digital tools. With the help of statistical techniques such as descriptive statistics and correlation analysis, the study aimed to measure how combining innovative ICT tools influences student involvement, engagement, and academic achievement at Malian institutions of higher learning.

2. Qualitative data

The analysis draws on the interview, focus group, and survey data of students and teachers, using thematic and narrative approaches. These they conclude that enable them to find patterns and further insights about how advanced ICT tools influence student engagement as well as perceptions, motivation, and learning. Adopted is a combined focus on understanding the determinants of ICT integration in Malian higher education and how to inform policies to yield students' learning performance.

F. Ethical Consideration

Before starting the research on the "Integration of ICT Advanced Media Tools for Academic Improvement and Student Engagement in Malian Higher Education," an ethical approval was granted by the Malian Ministry of Higher Education and concerned institutional boards. All subjects gave written, informed consent. Unique ID codes were given to protect participants'

privacy and confidentiality, and all data were secured. Participants were also told that they had a right to halt their participation in the study at any time, without obligation.

G. Limitations of the Study

First, the study is limited by a smaller sample size and is specific to a few institutions in Mali, and therefore it may not be generalizable to the entire higher education system. Furthermore, differences in technology infrastructure in institutions might impact the use and effectiveness of advanced ICT applications, thus affecting the study findings. Furthermore, ICT tools are rapidly developing, and therefore the results might soon be outdated; other external factors such as increased digital literacies of students or access to devices likewise may affect the results. Third, the study is likely vulnerable to biases due to its dependence on self-reported measures in terms of assessing student engagement and academic performance.

Results and Findings

A. Quantitative Data

1. Level of ICT Adoption and its effect on Student Engagement

From Table 1, private universities take the lead in ICT adoption (82% LMS and 75% faculty training), while teacher trainers' colleges are trailing way behind (33% for training participation and an average score of 2.5 on self-efficacy). While public higher education institutions exhibit average tool use (68%), they demonstrate alarmingly low access to training opportunities (52%), suggesting systemic disparities that require policy focus -- especially in the form of targeted required professional development and resource allocations—to address the digital divide within Mali's higher education.

Table 1. ICT uptake levels by type of institution

Type of Institution	Faculty (n)	ICT Adoption Score (Mean $\pm$ SD)	Digital Learning Platform Usage (%)	Interactive ICT Tool Adoption (%)	Student Engagement Index (%)
Public Universities	40	3.2 $\pm$ 0.8	68%	45%	52%
Private Universities	25	3.8 $\pm$ 0.6	82%	62%	75%
Technical Institutes	20	2.9 $\pm$ 0.9	55%	38%	41%
Teacher Training	15	2.5 $\pm$ 0.7	45%	30%	33%

Source: Personal Survey

2. Impact on Student Engagement

Table 2 shows that the fusion of more advanced ICT tools led to large improvements in student engagement in all areas measured, and particularly dramatic increases in students' participation in online discussions (+43%) and self-directed learning (+31%), indicating successful transformation of passive learners to active knowledge constructors by the digital media. There are strong positive correlations (r of 0.72–0.85) showing that increased use of

ICT positively correlates with both engagement behaviors, which is really important for more interactive and collaborative teaching as well as learning activities not always supported well in traditional classrooms.

Table 2. Student Engagement (N=150)

Engagement Metric	Pre-ICT (%)	Post-ICT (%)	Improvement	Correlation (r)
Class Participation	58	76	+18%	0.72
Assignment Completion	72	85	+13%	0.68
Online Discussion	25	68	+43%	0.85
Peer Collaboration	45	72	+27%	0.79
Self-Directed Learning	40	71	+31%	0.81
Course Satisfaction	65	84	+19%	0.74

Source: Personal Survey

3. Academic Performance Outcomes

The data show statistically significant differences in Table 3 for all the academic performance metrics following ICT-integrated studies; specifically, a noticeable growth rate was found in research output (+166.7%) and digital literacy (+67.8%), indicating that a technology-facilitated learning environment significantly improved not only traditional academic measures but also 21st-century skill development. The robust increases in graduation (+29.8%) and retention rates (+19.2%), all significant at $p < 0.01$ or beyond, demonstrate that ICT tools not only improve immediate learning outcomes but also support long-term student persistence and success in Malian higher education.

Table 3. Academic Performance Outcomes

Outcome Indicator	Pre-ICT Integration (Baseline)	Post-ICT Integration	Change (%)	Statistical Significance
Overall GPA (Mean)	2.45/4.0	2.78/4.0	+13.5%	$p < 0.001$
Course Completion Rate	68.4%	84.2%	+23.1%	$p < 0.01$
Graduation Rate (4-year)	52.0%	67.5%	+29.8%	$p < 0.001$
Student Retention Rate	74.3%	88.6%	+19.2%	$p < 0.01$
Exam Pass Rate	61.2%	79.8%	+30.4%	$p < 0.001$
Research Output (papers/student/year)	0.3	0.8	+166.7%	$p < 0.001$
Digital Literacy Assessment Score	42.5/100	71.3/100	+67.8%	$p < 0.001$

Source: Personal Survey

4. Facilitators of Successful Integration

Table 3 shows that administrative leadership commitment emerges as the strongest facilitator ($r = 0.78$), yet only 52% of institutions allocate dedicated ICT budgets, revealing a critical implementation gap between policy endorsement and resource mobilization. While LMS access is widespread (82%), inadequate technical support (58%) and blended learning adoption (63%) hinder optimal integration, suggesting that infrastructure availability alone

does not guarantee effective pedagogical transformation without concurrent investment in human capital and sustained institutional funding.

Table 4. Facilitators of Successful ICT Integration

Facilitator Category	Key Factor	Implementation Rate (%)	Impact Score (1-5)	Correlation with Performance
Infrastructure	Reliable internet connectivity	78%	4.6	$r = 0.72$
	Adequate computer labs/devices	65%	4.4	$r = 0.68$
	Learning Management System (LMS) access	82%	4.7	$r = 0.75$
Human Capital	Faculty ICT training programs	70%	4.5	$r = 0.71$
	Technical support staff availability	58%	4.2	$r = 0.64$
	Student digital skills workshops	74%	4.3	$r = 0.69$
Institutional Support	Administrative leadership commitment	85%	4.8	$r = 0.78$
	Dedicated ICT budget allocation	52%	4.1	$r = 0.61$
	Policy framework for ICT integration	68%	4.4	$r = 0.70$
Pedagogical Approach	Blended learning adoption	63%	4.5	$r = 0.73$
	Interactive digital content use	71%	4.4	$r = 0.67$
	Online assessment tools	69%	4.3	$r = 0.66$

Source: Personal Survey

B. Qualitative Data

1. ICT Adoption and Its Impact on Student Engagement

The under-usage of Moodle advanced functionalities can be explained by a lack of training and by the provision of specific support to this application; users will become more confident with it and thus produce better learning outcomes. Dr. Amadou K., School of Medicine, University of Bamako:

"We use Moodle essentially as a document repository, but the more advanced functionality (quiz, peer assessment and analytics) is little used because students or teachers do not know how to configure it."

Student Focus Group, University of Ségou:

"We access the notes on Campus. Although the internet is slow So we take a shot at night."

Interest is there, but WhatsApp groups work better on our phones

"We do not use WhatsApp as we should and the amount of interest you guys have shown."

Faculty of Agriculture:

“Students send assignments using Google Forms to save data, and we use Telegram bots for immediate feedback; assessment tools are practical according to our needs.”

The article commends the application of cost-effective tools to enhance student output and feedback, which gives an effective and flexible teaching technology.

“With the help of smartphones, we do everything, and sometimes it’s like a laptop”

Students at Sikasso’s University say

“We don’t have laptops, so with smartphones we manage. Office mobile apps so I can type up my thesis. We send each other parents the PDFs through Xender (offline file sharing) in parent-teacher meetings since bundles are too expensive for cloud risk.”

Well, that just proves that they use it for everything. I personally send PDFs through Xender because we are offline most of the time since the internet is too expensive to pay for cloud storage, and I used the Office mobile apps for my thesis.

“Low-end devices limit them to just 30% of students.” (Bamako’s University Dean).

The program to run virtual labs increases engagement, but only 30% of students can effectively do so from their devices, which points out a necessity to improve device compatibility or supply alternative methods for access. Here are things you can try out based on what interests you: Academia- Grad students from University of Bamako drop by

“Some of the professors have recommended ChatGPT to us for literature review and prompt engineering. It’s leading ICT and AI applied informally with VPNs to resist restrictions.”

2. Challenges and Barriers

Ongoing service shortfalls were referred to most frequently as a barrier. Faculty members described infuriating cycles of excitement followed by deflation when unreliable electricity or patchy internet marred planned exercises.

“You make an interactive, multimedia-embedded lesson and in the middle of delivering it the power goes.”

Furthermore,

“After three such experiences you might as well revert to chalk and talk”.

The digital divide that set campus technology in urban areas apart from those in the countryside intensified social and academic disparities, with institutions of Bamako enjoying an advantage and regional universities having to make do with outdated equipment and no broadband.

Resource constraints dominated any ICT integration conversation. Deans knew all too well that the upfront outlay on hardware and software was immaterial compared to total cost of ownership, but licensing costs for proprietary platforms blew most of the budget, and there were no local free solutions at hand.

“We got a generous donation of tablets,”
one administrator said,

“but we had no budget for fixing them, replacing them or buying data on the PIP. 60% were broken or obsolete within 2 years.”

A variety of entities—ministry, regulators and individual institutions—issued overlapping or conflicting directives.

“We get policy papers telling us to promote e-learning, yet exam regulations still presuppose paper-based examination.”

They were paralyzing in their confusion, for contradictory commandments rendered compliance futile. Organizational silos—IT overseeing infrastructure, academics’ teaching curriculum and the administration holding the purse strings—further eroded coherence, leaving innovation stranded in-between competing factions.

Pet habit pedagogical traditions die hard in the face of over-technologizing by industrialized and senior professors established

“When students can Google answers, what remains of the professor's expertise?”

one senior lecturer questioned. The resulting anxiety was evident in its shallowest forms: an adoption of PowerPoint as a digital chalkboard or the learning management system as a document repository that did nothing to alter instructional practices.

“Students have been socialized into certain passively-receptive approaches to learning which may militate against active, technology-enhanced pedagogies that require much more self-direction.”

(Lecturers)

The conflict between the implicit constructivist assumptions of ICT and the received didactic approaches produced implementation tensions that a narrow technical training can only avoid.

3. Academic Performance Outcomes

Other students emphasize

“Before ICT we were timid and quiet in class because we had more than 200 students in our classes. But in our WhatsApp group, we began explaining things through voice notes. Our involvement increased, even if the LMS stats do not reflect that – we’re out there in spaces the university doesn't measure.”

“ICT student use extends beyond simply clicking; it relates to active participation. Quieter students can end up driving advanced online discussions by comparing traditional literature with that found on modern social media.”

Department of Letters, rectors what is worth noting however, is this realization that ICT use could actually promote participation and leadership even among the shy and quiet when traditional culture converges with social media use, thereby facilitating learning.

“How the devices differ creates a digital divide that affects student engagement” (Faculty members).

Inequality in device access affects student participation for online engagement, and higher-performing devices are associated with more successful interaction. The divide needs to be bridged for education equity. Even the presence of stable internet access and sufficient ICT equipment does not automatically yield deep engagement; active involvement needs to be coached through intentional pedagogical strategies and thoughtful design.

“When our private internet came, I first became less engaged because I downloaded lectures and then watched, instead of following live sessions. To engage, it demanded AS intentional pedagogical design of access by ICT” (Students).

4. Facilitators of Successful Integration

Technological adoption was facilitated by university administrators with a clear vision who made specific resources available to that effect. As faculty members observed,

“When the rector took up the torch of digital transformation himself, departments were given moral permission to try out new tools.”

When ICT is aligned with pedagogical needs and various committees are included, implementation and adoption improve.

“We quit paying foreign consultants’ huge amounts of money who didn’t understand our infrastructure constraints. Our peer-to-peer training, in which tech-savvy faculty became coaches and mentored other faculty, established sustainable capacity.” (department heads)

Faculty were supported and exercised using ICT tools, as well as gained confidence.

Successful facilities devised innovative solutions to operate in an infrastructure-challenged environment rather than seeking the ideal.

“We stopped complaining about electricity and built solar computer labs.” (Rectors)

Using mobile-responsive applications for high penetration of smartphones, etc., and setting up special ICT labs with good power back up. Respondents stressed students considered digital tools important to the extent academic reward and assessment were overtly connected to technology-mediated tasks.

“Now that online discussions were a part of participation grades, engagement immediately flourished.”

The alignment with qualification levels and accredited status guaranteed adherence to institutional policy, positioning ICT integration as a quality and competitiveness criterion rather than just the experimental bonus.

Discussion

A. Effectiveness of particular ICT tools in the development of student participation and motivation

The use of innovative ICTs, namely e- learning platforms, mobile apps, and virtual labs, has shown promising results for increased student engagement and motivation in the higher education context in Mali. Past research has also found that such teaching tools promote an interactive and flexible learning environment that accommodates different learning styles, thus enhancing engagement [29]. E-learning platforms (such as Moodle, Coursera) support around-the-clock and around-the-world access to course content, encouraging self-directed learning and sustained engagement.

Mobile apps play an additional role in supporting informal learning, particularly for those regions lacking infrastructure, by helping to fill gaps in accessibility [30]. In contrast, virtual labs promote hands-on learning in a safe and controlled environment, offering increasingly confident and motivated students the opportunity to practice without time or space limitations [31]. All in all, these ICT tools lead to more inclusive and motivational learning, ultimately resulting in enhanced academic results and retention rates of students within their respective Malian HEIs.

B. ICT adoption levels and influencing factors in Malian HEIs

The adoption of advanced ICT tools in Malian Higher Education Institutions (HEIs) remains at a developing stage, influenced by a complex interplay of infrastructural, institutional, and socio-economic factors. Despite the increasing global recognition of ICT as a catalyst for improving student engagement and academic performance, Malian HEIs face significant challenges such as limited technological infrastructure, insufficient digital literacy among faculty and students, and financial constraints [21]. Additionally, institutional resistance to change, lack of strategic policies, and inadequate training programs further hinder effective ICT integration [32].

Conversely, factors such as government initiatives aimed at digital transformation and increasing mobile technology penetration present opportunities for enhancing ICT adoption [33]. Understanding these influencing factors is crucial for designing tailored strategies that promote the effective integration of advanced ICT tools, ultimately fostering a more engaging and high-performing academic environment in Malian HEIs.

C. Issues And Constraints Faced by Institutions and Students

The deployment of sophisticated ICT tools in Malian universities raises several infrastructure, technical, and pedagogical issues that limit their capacity to improve the participation and learning experiences among students. Structurally, most organizations are faced with limited internet access, limited access to state-of-the-art devices and digital infrastructure, hindering the massive acceptance of modern ICT platforms [34]. Technically, a significant barrier is the lack of technical expertise among faculty and students, leading to underutilization of available tools and low digital literacy levels [35].

In pedagogical terms, there is a gap between the existing teaching practices and what advanced ICT tools can do, with few students' adoption and learning outcomes to show for it due partly to inhibitory resistance to change and insufficient in-service training [36]. These obstacles must be addressed through an inclusive strategy aimed at improving infrastructure, developing technical capacity, and fostering pedagogical innovation adapted to the objectives of digital transformation in order to guarantee sustainable integration of ICT within Malian higher education.

D. Impact of advanced ICT tools on student engagement and achievement

The integration of advanced ICT tools in Malian higher education significantly enhances student engagement and academic achievement by fostering interactive and personalized learning environments. These technologies, including digital platforms, multimedia resources, and e-learning systems, facilitate active participation, collaboration, and immediate feedback, which are crucial for improving learning outcomes [37]. Moreover, the adoption of ICT tools addresses challenges such as limited access to quality educational resources and geographical barriers, thereby promoting inclusivity and motivation among students [38].

Empirical studies indicate that when effectively integrated, ICT enhances critical thinking, problem-solving skills, and overall academic performance, especially in resource-constrained settings like Mali [39]. Therefore, leveraging advanced ICT tools in Malian higher education not only increases student engagement but also contributes to achieving educational excellence and sustainable development goals [40].

E. Policy and practice recommendations for enhancement**1. Policy makers and educators**

Policymakers must work with educators to build holistic policies which leverage advanced ICT tools in support of student engagement and academic success in the Malian HE context. Policymakers have to focus on developing enabling environments that enable the uptake of novel digital solutions with equitable access in various geographical regions [41].

Teachers require specific professional development programs for the desirable use of these tools that foster interactive and student-centered learning situations [42].

2. Students and technology providers

As primary users of technology providers, learners should contribute to co-creation in producing digital learning experiences that meet their needs and align with their preferences, thus stimulating motivation and engagement [43]. For its part, technology specialists should work on providing ICT solutions that are locally relevant and user-friendly and grapple with infrastructure- and language-specific barriers in Mali. In general, a multiple-stakeholder strategy focused on policy backing, development support, student participation, and technological relevance is required to get the maximum out of advanced ICT tools in Higher education institutions to guarantee sustainable academic enhancements [44].

Recommendations

1. It is Time You Developed a Robust Digital Infrastructure and Access Policy. Ensure access to reliable internet and necessary ICT tools in higher education institutions in Mali. This fundamental approach guarantees that all staff and students can use a well-advanced ICT toolkit to narrow the digital divide and enhance inclusive participation.
2. Develop Value-Based Faculty Training and Development. Provide long-term training for teachers to be able to implement advanced multimedia into their teaching. Teaching teachers digital pedagogy will create dynamic teaching and learning environments, greater student involvement, and better academic results.
3. Use of Student-centered and Interactive ICT tools. Develop and disseminate interactive e-learning platforms, virtual labs, as well as multimedia resources that cater to individual learning styles. These tools can be used to make learning more interactive and entertaining, encourage active participation, and improve comprehension of complicated subjects.
4. Promote Policy and Curriculum for Digital Integration. Adapt current curricula to include teaching and learning activities that are based on ICT, while creating institutional strategies towards incorporating digital literacy. Incorporating ICT integration into curricular standards will help establish technology use in schools and ensure that the benefits of the technology persist.
5. Implement Perpetual Monitoring and Feedback Processes. Develop mechanisms to continuously review the impact of ICT tools on engagement and outcomes. Request feedback from students and faculty to inspire iteration and ensure that the solutions are useful, easy-to-use, and effective.

Conclusion

The use of state-of-the-art ICT in Malian Higher Education is offering tremendous promise for improving learner engagement and performance, notwithstanding grave infrastructure-, logistical-, and institutional-related hurdles. The study results reveal that students' participation, learning outcomes, and digital literacy are significantly enhanced if e-learning platforms, mobile applications, and new technologies such as AI and virtual reality have been strategically implemented. But reaping the benefits will require coordinated action to overcome connectivity challenges, scale faculty training, find reliable funding sources, and transform pedagogical practices. Through these policy frameworks, building capacity initiatives and student-centered digital strategies, Malian institutions for higher education could address the digital divide and promote inclusive learning environments to prepare students just as necessary to succeed in an ever-growing digital global economy.

Conflict of Interest

The authors declare no conflict of interest.

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