Investigating the integration of digital devices to enhance learning material accessibility in higher education: An experience from Jordan University College students, Tanzania

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ABSTRACT

This paper investigates the integration of digital devices to enhance access to learning materials in Tanzanian higher education, focusing on students' experiences. Many universities have been equipping their students with digital devices; however, there is little documentation on their use. While this study was guided by the Unified Theory of Acceptance and Use of Technology (UTAUT), it employed a mixed-methods approach. Using questionnaires, interviews, and observations, rich data were collected and analyzed from a sample of 359 students, calculated using Yamane's formula, from a total of 3500 students at Jordan University College (JUCo). The data analysis used SPSS to assess the impact of digital device integration on the accessibility of learning materials and to understand the mediating roles of technological proficiency and learning style. The findings showed that about 45% of the students in the selected sample have access to digital Materials using Smartphones, and the remaining percentage use other digital devices. Also, about 36% of students rely heavily on traditional hard-copy materials for learning, and the remainder is due to other challenges. Furthermore, about 75% of students have positive attitudes toward using digital devices for Learning and global connectivity, while 25% have negative attitudes. About 56% of students have 1 to 3 years of experience using digital devices for learning. Overall, this research illuminates the complex dynamics of using digital devices to improve access to learning materials in Tanzanian higher education. Technological integration can improve accessibility and student experiences, but financial and digital literacy issues must be addressed. To maximize the use of digital devices in education, several issues must be addressed. Policymakers and educators should work together to promote digital literacy and equal access to digital resources. To ensure that all students benefit from educational technology, the digital divide must be bridged, especially in financially disadvantaged areas. This research adds useful insights to the ongoing conversation on the integration of digital devices in education, presenting practical recommendations to better the learning experience for Tanzanian Higher students. According to the study's findings, the government of Tanzania should strongly consider strengthening information and communication technology (ICT) infrastructure in its public institutions and equipping universities with more ICT workers. It is recommended that students make excellent use of the resources available to them at their respective educational institutions.

Keywords: Digital Devices, Digital Materials, Digital Resources, Higher Education, Learning Materials, Student Experience

I. INTRODUCTION

In the 21st century, the world has undergone a technological revolution, reshaping how we live, work, learn, and access information (Seethal & Menaka, 2019). This revolution is evident in many aspects of human life across countries worldwide, where the integration of Information and Communication Technology (ICT) plays an increasingly crucial role in driving further advancements. These advancements have significantly impacted diverse sectors such as agriculture, industry, mining, health, and education, reshaping the way people live, work, and learn (Islam & Jahan, 2018). In agriculture, precision farming has emerged as a game-changer, leveraging technologies like Global Positioning Systems (GPS), sensors, and data analytics to optimize crop management. Farmers can now make data-driven decisions on irrigation, fertilization, and pest control, resulting in increased productivity and resource efficiency (Seethal & Menaka, 2019). In the industry sector, the industrial landscape has witnessed the advent of Industry 4.0, marked by the integration of artificial intelligence (AI), the Internet of Things (IoT), and automation (URT, 2018). This not only boosts efficiency but also facilitates the development of customizable and on-demand production. In business, technology has become an integral part of the business ecosystem, transforming operations, communication, and customer engagement (Perini, 2015).

Moreover, advanced analytics and machine learning algorithms empower businesses to extract valuable insights from massive datasets, facilitating informed decision-making. In the mining sector, technological advancements have led to safer and more efficient extraction processes. Automation and remote-controlled machinery enhance worker safety in hazardous environments, while drones and satellite imagery aid in geological surveys and monitoring. The healthcare sector has not been immune to the technological revolution, which has witnessed the rise

of telemedicine, wearable devices, and health informatics (Islam & Jahan, 2018). Similarly, in the education sector, technology has revolutionized learning methodologies, providing access to information on a global scale and curriculum development. Many studies try to link education and technology, having largely focused on integrating technology in the curriculum in the education context (Bond & Bergdahl, 2023).

In the education context, the advent of Information and Communication Technology (ICT) has triggered a revolutionary transformation. The advent of the internet and advanced technology has brought about a revolutionary change in the education sector (Seethal & Menaka, 2019). Universal access to information through the internet and digital resources, coupled with virtual classrooms and e-learning platforms, has redefined the learning landscape. This paradigm shift in education is fundamentally altering the educational environment to meet the dynamic demands of the modern world, to ensure widespread access to quality learning materials (Sariyatun et al, 2021). Access to quality learning materials is a fundamental pillar in shaping students' academic journeys worldwide. In various countries, access to learning materials plays a crucial role in education. For instance, in developing countries, despite technological advancements for enhancing learning experiences, the accessibility of learning materials remains a critical challenge (Ozden, 2018). To address this gap, exploration is required to understand the potential of digital-based devices to enhance accessibility to digital learning materials.

Digital learning materials are digitized and interconnected learning resources. The digitalization of learning material supports teachers and students' activities to achieve the learning objective of social studies learning (Sariyatun, et al, 2021). Digital devices like e-books, tablets, and online platforms can bridge this accessibility gap (Elfeky & Masadeh, 2016). They provide students with a more accessible array of educational materials, ensuring that students, regardless of their location, can access textbooks, research articles, and multimedia content. Individuals in the 21st century encounter digital devices in every aspect of life. Through digital means, the education system can effectively address the existing gap in access to learning materials, especially in developing countries like Tanzania.

In Tanzania, higher-level students face significant challenges in obtaining learning materials such as textbooks and pamphlets. Since students are required to purchase them from bookshops, they are unable to access them due to financial constraints. This limited access to learning materials hinders their academic progress and educational opportunities (Higgins & Bushell, 2018). Despite technological advancements for enhancing learning experiences, accessibility to learning materials remains a critical challenge (Elfeky & Masadeh, 2016). This study aims to address this gap by exploring the potential of digital-based devices such as smartphones, tablets, and laptops as tools to improve the current status of learning material accessibility.

Currently, access to learning materials in Tanzania faces several challenges, particularly for digital resources. Those resources serve as the primary reference point for gaining knowledge, understanding concepts, and completing work (Islam & Jahan, 2018). Reliance on hardcopy materials like textbooks and pamphlets is associated with the cost of purchasing these materials and with limited access for those who cannot afford them. Additionally, the static nature of hardcopy materials limits students' ability to engage with dynamic, interactive learning resources readily available online. This gap often stems from geographical constraints, a lack of diverse digital learning materials, and limited resources.

The increasing importance of digital resources in global education requires a comprehensive understanding of the gap, focusing on the challenges, attitudes, and impacts of using digital devices for learning (Shenoy & Jhal, 2016). This can be done as a study intended to bridge existing gaps by examining the role of digital devices in facilitating access to learning materials (Higgins & Bushell, 2018). Findings from the study seek to provide evidence-based recommendations that can positively impact educational practices and an effective learning environment for Tanzanian Higher students. Consequently, this study provides vital insights to educational stakeholders, policymakers, and institutions to enhance the overall learning experience amid the digital revolution. Despite this digital revolution, Higher-level students in Tanzania face challenges accessing crucial learning materials. To address this gap, digital devices in the educational landscape emerge as a potential remedy to these challenges. This study emphasizes the pivotal role of digital devices like smartphones, laptops, and tablets in addressing material accessibility issues (Elfeky & Masadeh, 2016).

1.1 Research Questions

i. What are the challenges faced by students in the current state of learning material accessibility?
ii. What are the attitudes of students towards the use of digital devices for learning?
iii. What is the impact of using digital devices in enhancing learning material accessibility?

II. LITERATURE REVIEW

2.1 Theoretical Review

Collis and Hussey (2013) state that every study is based on a theoretical framework. This study was guided by the Unified Theory of Acceptance and Use of Technology (UTAUT), as discussed below

2.1.1 The Unified Theory of Acceptance and Use of Technology (UTAUT)

The conceptual framework for this study, which centers on exploring the use of digital devices to enhance the accessibility of learning materials in Tanzanian higher education, draws inspiration from the Unified Theory of Acceptance and Use of Technology (UTAUT). UTAUT, developed by Venkatesh et al. (2003), provides a comprehensive framework for understanding the factors influencing the acceptance and adoption of technology. In this context, UTAUT serves as a theoretical foundation for investigating the acceptance and use of digital devices, such as tablets, in educational settings. Key Components of the Unified Theory of Acceptance and Use of Technology (UTAUT) include Performance Expectancy (PE, Effort Expectancy (EE), Social Influence (SI), and Facilitating Conditions (FC).

In addition, the Unified Theory of Acceptance and Use of Technology (UTAUT) provides a robust theoretical framework for understanding the complex interplay of factors that influence the acceptance and adoption of digital devices in Tanzanian higher education. By incorporating key components of UTAUT, the proposed framework guides the investigation into teachers' and students' attitudes toward the use of digital devices, offering insights into performance expectations, effort expectations, social influence, and facilitating conditions. This model enhances the research's capacity to analyze and interpret the multifaceted nature of integrating digital devices into the teaching and learning process. Creating a visual representation of the Unified Theory of Acceptance and Use of Technology (UTAUT) model involves illustrating the key components and their relationships (as detailed in Figure 1 below)

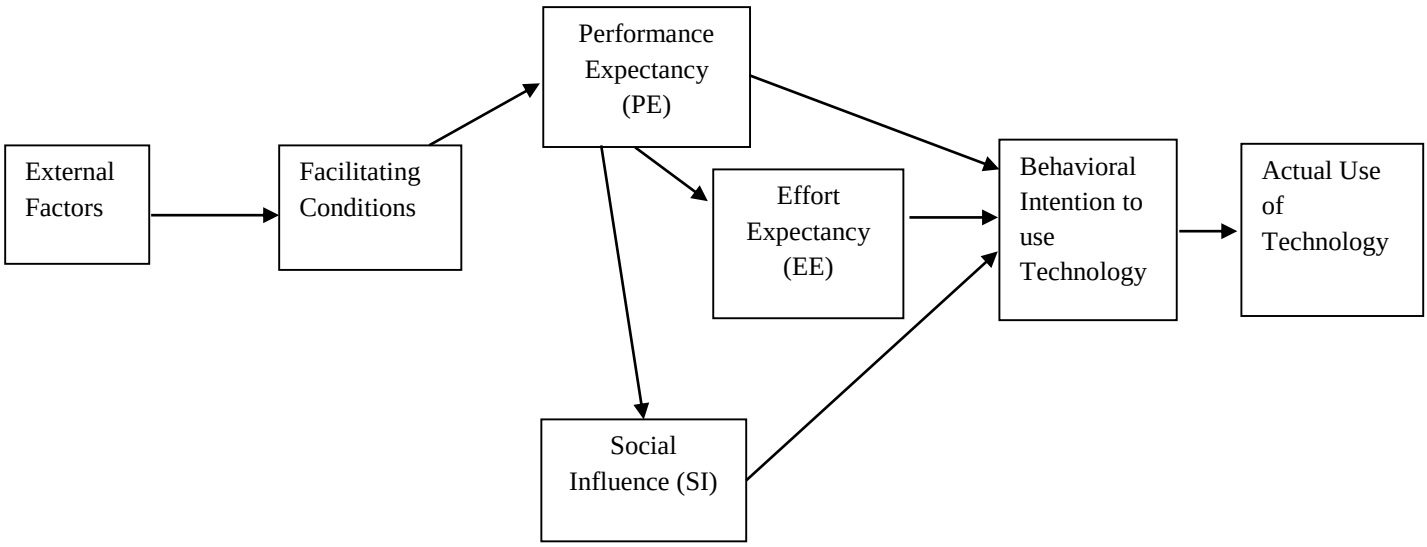

Figure 1
Unified Theory of Acceptance and Use of Technology Model

2.2 Empirical Review

2.2.1 Learning Materials Accessibility Challenges

The term “Learning Material Accessibility” examines how technology, particularly digital tools, helps make learning materials more accessible to a diverse range of learners. Beyond the hardware, learning material Accessibility navigates the realm of software, platforms, and design, spotlighting the transformative potential of technology in making educational content more accessible. It delves into the nuances of inclusivity, adaptability, and user-friendliness, emphasizing not just the availability but the ease with which learning materials can be accessed. This encapsulates the core mission to improve the accessibility of learning materials through the utilization of digital devices. It involves an examination of inclusive design, digital formats, and platforms that cater to varied learning needs.

Despite technological strides, Tanzanian Higher-level students face substantial obstacles to accessing essential learning materials, such as textbooks and pamphlets, primarily due to financial constraints (Higgins & Bushell, 2018). The study emphasizes that the limited access to learning materials hampers academic progress and restricts educational opportunities for these students. Furthermore, reliance on traditional hardcopy materials hinders

adaptation to dynamic, interactive online resources, reflecting broader issues related to geographical constraints and the scarcity of diverse digital learning materials.

Technology in Education encompasses a diverse array of tools, applications, and platforms used to facilitate and enhance the educational process. Amid these transformations, the education sector has undergone a profound paradigm shift, particularly with the advent of the internet, advanced technologies, and the digitization of learning materials (Seethal & Menaka, 2019). This term explores the integration of digital advancements such as computers, tablets, software, and online resources into instructional methods, aiming to understand the broader landscape and trends shaping the intersection of technology and education.

Seethal and Menaka (2019) dive into the captivating realm of digitalized education in the 21st century, posing a crucial question: Is it a boon or a bane for India's educational landscape? Their research delves into the burgeoning influence of the internet and technology on shaping educational practices, offering intriguing insights for educators, policymakers, and learners alike. Seethal and Menaka dissect the two sides of the digitalization coin, meticulously weaving together the pros and cons of this transformative approach. However, the authors don't shy away from acknowledging the potential challenges. Concerns regarding digital divide, inequitable access to technology, and the ever-present question of the human touch in education are explored with nuance. This balanced perspective adds depth and credibility to their arguments, avoiding simplistic pronouncements and instead fostering critical reflection. Seethal and Menaka's (2019) work seems to have a limited Scope since it mainly focuses on the Indian context, neglecting the broader global perspective on digitalized education.

Moreover, Saiful Islam and Nusrat Jahan's work on the impact of digitalization on education in Bangladesh shines a light on this crucial and ever-evolving landscape. Their research, titled "Digitalization and Education System: A Survey," delves into the perceptions and experiences of students, offering valuable insights for educators, policymakers, and researchers alike (Seethal & Menaka, 2019). This work seems to have some weakness in analytical depth, as it briefly acknowledges challenges such as the digital divide and unequal access but doesn't delve deeper into these crucial issues or their impact on the findings. Also, it overlooks ethical considerations regarding data privacy and the potential misuse of digital tools in educational settings. In the context of Tanzanian education, technology is harnessed especially at higher-level schools (Bond & Bergdahl, 2023). This involves an exploration of Higher learning management systems, virtual laboratories, and specialized software tailored to higher subjects. This shows how technology can facilitate research, collaboration, and knowledge dissemination at a higher academic tier (Imamoglu, 2024). The integration of emerging technologies like artificial intelligence and data analytics in Higher education settings, addressing the unique challenges and opportunities specific to Tanzanian Higher education.

The integration of Information and Communication Technology (ICT) in education is a transformative process, and students play a crucial role in its success (Bond & Bergdahl, 2023; Imamoglu, 2024). Their engagement and adaptability to technology shape the effectiveness of ICT integration. However, this involvement comes with challenges and imperatives that influence the overall outcome of incorporating technology in educational settings. Students' role in ICT integration is multifaceted. They serve as active participants, digital learners, and contributors to the learning process. Their responsibility includes adapting to new technologies, utilizing digital resources, and collaborating through online platforms (Higgins & Bushell, 2018). Students also play a role in providing feedback, which informs improvements to ICT tools and strategies to enhance learning experiences. One of the challenges in this context is the digital divide, where not all students have equal access to technology. Economic disparities and varying levels of technological infrastructure create disparities in students' ability to engage with ICT tools. Bridging this gap is imperative and demands efforts to ensure equitable access to devices and internet connectivity for all students.

Moreover, students may face challenges related to digital literacy. While the younger generation is often considered tech-savvy, not all students possess the necessary skills to navigate complex digital environments critically. Educational institutions must prioritize digital literacy programs to empower students to use ICT tools effectively and responsibly (Islam & Jahan, 2018). Another challenge lies in the potential distraction posed by technology. Students may be tempted to deviate from educational purposes and engage with non-educational content during online learning. Striking a balance between using technology for learning and minimizing distractions requires cultivating digital discipline and emphasizing the imperative of responsible technology use. Despite these challenges, the imperatives for students in ICT integration are clear. They must actively participate in their learning journey by embracing and adapting to evolving technological landscapes. Cultivating a mindset of curiosity and a willingness to explore various digital tools is essential (Higgins & Bushell, 2018). Additionally, students must advocate for equitable access to technology to foster an inclusive learning environment. Addressing challenges such as the digital divide and promoting digital literacy are imperatives that require collaborative efforts from educational institutions, policymakers, and the students themselves. By recognizing and addressing these challenges, students can contribute significantly to creating a technologically enriched and equitable learning environment.

2.2.2 The Attitudes of Students Towards the Use of Digital Devices for Learning

Understanding students' attitudes toward integrating digital devices is crucial for overcoming accessibility challenges. Existing literature suggests that incorporating digital devices positively influences student-teacher relationships, conversational skills, and academic improvements (Higgins & Bushell, 2018). However, the specific attitudes of Tanzanian Higher students towards digital devices and their perceived impact on the accessibility of learning materials remain areas for exploration in this study. The focus on "student experience" underscores a user-centric approach, delving into the firsthand encounters, challenges, and benefits that students in Tanzanian Higher education encounter as they engage with digital learning materials.

Ria et al (2024) in their study on Students' attitudes towards use of ICT as a tool of learning using a structural equation modelling (SEM) approach, found that two external variables indirectly influence students' attitudes towards ICT use, but perceived ease of use and self-efficacy had a direct and positive impact on perceived usefulness. These variables positively and significantly influence students' attitudes towards ICT as a learning tool. Most of our students prefer the ease of use and quick usefulness of digital devices. Also, Naveh and Shelef (2021) analyzed students' attitudes toward using technology for learning, emphasizing simplicity as the key to successful implementation. Naveh and Shelef (2021) found that students extensively use a variety of technologies for learning. They prefer to use the same technologies for learning that they use in their personal lives – mainstream, commercially available technologies – rather than those offered by the institute. They perceive technology as a learning tool more than a logistical/administrative tool; they would like it to be more easily accessible and not to be used as a facilitator of pedagogical change.

In this context, technological development is evaluated based on its impact on the holistic learning experience, encompassing accessibility, engagement, and overall educational outcomes. This literature review synthesizes existing knowledge, highlighting the potential of digital devices to overcome challenges related to the accessibility of learning materials in Tanzanian higher education. The subsequent sections of the research will delve into empirical investigations, seeking to provide evidence-based recommendations for educational stakeholders and policymakers. By addressing the identified gaps, the study aims to contribute valuable insights to enhance the overall learning experience for Tanzanian higher education students amid the ongoing digital revolution.

2.2.3 The Impact of Using Digital Devices in enhancing Learning Material Accessibility

Digital learning materials, defined as digitized and interconnected resources, have emerged as transformative tools in reshaping the educational landscape (Sariyatun et al., 2021). "Digital Devices" refers to hardware components, including, but not limited to, laptops, tablets, smartphones, and other electronic devices used in educational settings. This term examines the functionalities and roles of these devices, shedding light on how they contribute to the learning environment and influence pedagogical approaches. The integration of digital devices including e-books, online platforms, tablets, and laptops, holds promise in addressing the persistent challenge of accessibility to quality learning materials, transcending geographical and financial barriers (Elfeky & Masadeh, 2016). These tools have the potential to provide a more inclusive and flexible educational experience, offering students access to textbooks, research articles, and multimedia content irrespective of their location. The emphasis on the Use of digital devices underscores the technological aspect, drawing attention to the varied electronic tools and gadgets that have become omnipresent in the educational landscape (Perini, 2015). Tablets, laptops, and smartphones are not just hardware; they are conduits through which technological advancements are channeled into learning.

Digital technologies and devices have changed the nature and scope of education and led education systems worldwide to adopt strategies and policies for ICT integration (Timotheou et al., 2022; Zafer et al., 2025). The latter raised issues regarding the quality of teaching and learning with ICTs particularly concerning the understanding, adaptation, and design of education systems in line with current technological trends. These issues were emphasized during the recent COVID-19 pandemic, which accelerated the use of digital technologies in education, generating questions regarding digitalization in schools. Specifically, many schools demonstrated a lack of experience and low digital capacity, which resulted in widening gaps, inequalities, and learning losses. Such results have underscored the need for schools to learn from and build on these experiences to enhance their digital capacity and preparedness, increase their level of digitalization, and achieve a successful digital transformation. Given that the integration of digital technologies is a complex and continuous process that impacts different actors within the school ecosystem, there is a need to show how these impacts are interconnected and identify the factors that can encourage an effective and efficient change in the school environments (Timotheou et al, 2022; Terras & Ramsay, 2015).

The integration of digital learning tools in school science classes has garnered significant attention, prompting an investigation into their effects on student engagement and achievement. Zafer et al. (2025) in their study examined the impact of students' access to technology, teachers' digital competency, and the frequent use of digital tools; findings indicate that access to technology, teachers' digital competency, and the frequent use of digital tools positively influence student engagement and achievement in science. Digital tools significantly enhance engagement by providing interactive, personalized learning experiences, thereby increasing students' motivation and interest.

Furthermore, improved academic outcomes are evident in higher test scores and performance in science assessments. Teachers also noted a positive shift in classroom dynamics, characterized by increased collaboration and inquiry among students. These results highlight the critical need for ongoing investment in educational technology and professional development for educators to fully leverage the benefits of digital learning tools

In another study by Haleem et al. (2022), a review of the role of digital technologies in education, the authors concluded that these technologies have had a powerful impact on the education system. The recent COVID-19 Pandemic has further institutionalised the applications of digital technologies in education. These digital technologies have made a paradigm shift in the entire education system. It is not only a knowledge provider but also a co-creator of information, a mentor, and an assessor. Technological improvements in education have made life easier for students. Instead of using pen and paper, students nowadays use various software and tools to create presentations and projects. When compared to a stack of notebooks, an iPad is relatively light. When opposed to a weighty book, surfing an E-book is easier. These methods help increase interest in research. This paper briefly discusses the need for digital technologies in education and examines major applications and challenges.

The transformative phase of technology led to changes in various sectors worldwide. For instance, the use of Information and Communication Technology (ICT) in agriculture enables precision farming techniques, like using drones and sensors, to optimize crop management, irrigation, and pest control, leading to increased productivity and reduced waste. In industry, ICT allows efficient supply chain management and smart production techniques, enhancing productivity while reducing costs and errors (Kaur, 2017). In the health sector, ICT has revolutionized healthcare by improving patient care, enabling remote consultations, monitoring health metrics, and facilitating quicker, more accurate diagnoses. In mining, ICT has brought significant changes, particularly in exploration and extraction, where drones, automation technologies, and sensors are used to increase efficiency (Kaur, 2017). Not only that, but ICT also enables the use of detailed data on mining extraction areas, thereby improving extraction techniques (Kaur, 2017). While there's potential for ICT to revolutionize various sectors, there are gaps in its widespread adoption and integration, and these gaps are due to limited technological infrastructure, where rural areas often lack adequate internet connectivity, restricting access to ICT tools and information for communities, even in the education sector (Zafer et al, 2025; Ria, 2024).

Also, in their study, Timotheou et al. (2022), in their review of the Impacts of digital technologies on education and factors influencing schools' digital capacity and transformation, found that ICT integration in schools affects more than just students' performance; it also affects several other school-related aspects and stakeholders. Furthermore, various factors affect the impact of digital technologies on education. These factors are interconnected and play a vital role in the digital transformation process. The study results shed light on how ICTs can contribute to the digital transformation of schools and on the factors that schools should consider to achieve effective, efficient change.

Sariyatun et al. (2021) discuss the intriguing impact of digital learning materials on the development of students' social skills in the context of social studies education. The authors acknowledge the crucial role that social skills play in navigating social interactions and contributing effectively to society. They also recognize the growing trend of digitalization in education and its potential benefits for learning. However, a critical question arises: how can digital learning materials effectively foster students' social skills, given that social studies inherently require social interaction and communication? The central question driving this research is whether digital learning materials can demonstrably improve students' social skills compared to traditional printed textbooks in social studies. To address this, the authors employ a quantitative comparative method, dividing 80 higher education students into two groups: one using digital learning materials and the other using printed textbooks. It aims to inform and engage readers interested in the evolving landscape of social studies education and the transformative potential of digital learning.

Furthermore, various scholars examine digital learning materials, drawing on research by Timotheou et al. (2022) and Sariyatun et al. (2018) to highlight their growing acceptance and potential benefits, including enhanced motivation, deeper understanding, greater accessibility, and greater autonomy. The notion of students as "digital natives," immersed in online interaction and communication, is also introduced, underscoring the need for social skills to navigate digital learning environments.

In summary, when thoughtfully implemented, digital devices offer several advantages in the classroom. Firstly, enhanced engagement and motivation, whereby interactive applications, educational games, and multimedia content typically hold students' attention better than traditional lectures. Studies show 76% of students report that technology makes lessons more engaging, and teachers observe increased participation, particularly from students who might be hesitant to speak up in conventional settings. Secondly, by offering personalized learning at scale with 1-to-1 device access, teachers can tailor assignments to individual learning paces and levels. Adaptive learning software can adjust difficulty in real time, providing targeted practice where needed. Research has found statistically significant gains in writing quality, science understanding, and math achievement in schools with comprehensive device programmes. Thirdly, improve accessibility and inclusion. Digital devices accommodate diverse learning needs through built-in accessibility features like text-to-speech, magnification, and translation tools. Students with learning

differences can use specialised applications to support their comprehension, while English language learners benefit from instant access to definitions and translations. Fourth, the use of digital devices offers extended learning opportunities. Cloud platforms and digital resources allow learning to continue beyond school hours. Students who are absent can still participate remotely, and recorded lessons provide valuable review materials. Parents gain greater visibility into what their children are learning, facilitating home support. Finally, the use of digital devices facilitates the development of future-ready skills. Through technology-based projects, students practice critical digital literacy, research, collaboration, and creative skills that prepare them for higher education and careers in an increasingly digital world.

III. METHODOLOGY

3.1 Research Design

A qualitative-quantitative case study was provided. The research utilized a mixed-methods design. This methodology combines qualitative and quantitative research techniques to thoroughly address the research enquiries. Given the study's complexity and emphasis on student experiences, a synthesis of quantitative data and qualitative insights is required. Quantitative research yields statistical metrics, whereas qualitative research explores the underlying reasons for events, providing deeper, more meaningful insights.

3.2 Study Area

This study was conducted at Jordan University College (JUCo) in Morogoro, Tanzania. JUCo is a campus of St. Augustine University of Tanzania. It is located on Dar es Salaam Road, approximately 3 km from Morogoro City center, and has more than 3,500 students.

3.3 Target Population

The study target population was Jordan University College (JUCo) in Morogoro. JUCo is a constituent college of St. Augustine University of Tanzania, located in Morogoro, Tanzania. It was established by the Salvatorian Mission. The college provides higher education in philosophy, theology, and other fields, offering a Catholic-based education focused on academic, moral, and spiritual growth.

3.4 The Sampling Method

The study used simple random sampling. Sarfo et al (2022) suggest that the research sample must exhibit all characteristics of the target population to be representative. Therefore, retaining such traits greatly improves the reliability of findings. Sarfo et al (2022) suggest that accounting for all qualities of auxiliary variables is another key requirement for sample representativeness. Auxiliary variables improve the estimation of sample formation (Zrineh et al, 2026). The sample comprises all students from the first year to the last year in various academic programs. This approach guarantees representation across several academic fields, fostering a comprehensive understanding of the student experience with digital devices. Participants will be selected based on their experience with digital devices in educational settings, ensuring a diversity of viewpoints.

3.4.1 The Size of the Sample

As detailed below, this study used a formula. Yamane (1967) presents the formula for determining sample size based on population size and margin of error as follows:

$$n=\frac{N}{1+N(e)^2}$$

Where: n = Sample Size,
N= Population Size
e = Margin of error

Since the population of JUCo is approximately 3500 students, the sample size was calculated as follows:

$$n=\frac{3500}{1+3500(0.05)^2}$$
$$=358.974$$

Since a sample size must be a whole number, we round up. The total sample size, after rounding up, is n = 359. Therefore, for a population of size 3500, you'll need a sample size of 359 participants

Table 1

A Selected Sample of 364 Students

Target Population Gender	Frequency (f)	Percent (%)
Male	156	43.5
Female	203	56.5
Total	**359**	100.0

3.5 Data Collection

This study used a closed- and open-ended questionnaire, interviews, and observations. The study employed structured closed and open-ended questionnaires to quantify students' experiences with digital devices, accessibility to learning materials, and general views. Likert scales and multiple-choice formats were adopted to facilitate the statistical analysis of responses. The interviews also included biographical and open-ended inquiries. Comprehensive interviews were conducted with a select group of survey respondents. These semi-structured interviews examined students' perspectives, obstacles encountered, and intricate experiences using digital gadgets in greater detail. Classroom observations were conducted to evaluate the practical integration of digital devices in the learning environment. This qualitative data will enhance survey and interview results, offering a comprehensive perspective on the digital learning environment.

3.6 Data analysis Techniques

The qualitative and quantitative data were analyzed individually in NVivo and SPSS. The results were discussed after merging. A protected file stores respondent surveys for easy access. Online data were easily imported into Microsoft SQL and coded according to the study instrument objectives. The following shows data analysis.

3.7 Ethical Considerations

Every participant in this study was informed prior to data collection. Participants were fully informed about the study's purpose and procedures, and their consent was obtained before data collection. Also, data collection was conducted with anonymity and Confidentiality. All collected data were anonymized to protect participants' identities, and confidentiality was maintained throughout the study. Finally, participation in this study was Voluntary. Students' participation in the study was entirely voluntary, and they could withdraw at any stage without facing any consequences.

IV. FINDINGS & DISCUSSION

4.1 Demographic Information of Respondents

Table 2 provides demographic insights into the respondents, offering a snapshot of gender distribution, gender category, educational attainment, program of study, and years of work experience. These demographic factors are essential for shaping the understanding of digital device use in learning.

Table 2

Demographic Characteristics of Respondents

Variable	Category	Frequency	Percentage
Gender	Male	156	43.5
	Female	203	56.5
	Total	**359**	**100**
Education level	Diploma	92	25.6
	Bachelor Degree	193	53.8
	Master Degree	71	19.8
	Doctorate	03	0.8
	Total	**359**	**100**
Program of Study	Education & Religious	99	27.6
	Laws	60	16.7
	Technology	43	12.0
	Accounting & Finance	73	20.3
	Theology	41	11.4
	Business	43	12.0
	Total	**359**	**100**

The demographic characteristics presented in Table 2 provide a clear picture of the respondents. Each of the three variables, gender, education level, and the program of study, plays a significant role in shaping the integration of digital devices in learning.

4.2 Gender Distribution

The gender distribution of respondents, as shown in Table 2, shows slight female dominance, with 56.5% males and 43.5% females, suggesting that gender can influence the integration of digital devices in a university. Recently, there has been a significant push to increase female enrollment in universities (URT, 2004). Hopeful this is facilitated by the fact that, in business and education studies, there are more women than men (Shapiro, 2019).

4.3 Educational Level

As you can see from Table 2 above, the majority of respondents are bachelor students (53.8%), with fewer doctorate students (0.8%). This higher level of educational attainment may correlate with a greater understanding and ability to utilize complex information systems. According to research by Sarfo (2022), higher education levels often correlate with greater technical proficiency and the ability to engage critically with technology, suggesting that the majority of respondents are likely equipped to utilize and assess digital devices. Moreover, research indicates that higher levels of education correlate with enhanced critical thinking and analytical skills, which are essential for understanding and utilizing digital devices in educational contexts. Moreover, professionals with advanced degrees are more likely to adopt innovative technologies and practices, thereby improving the effectiveness of education project monitoring.

4.4 Program of Study

Respondents' program of study shows a fair distribution. The majority of students are in education and religious studies (27.6%), which could be due to the fact that JUCo is a religious and educational institution (founded for). Other programs are Laws (16.7%), Technology (12.0%), Accounting & Finance (20.3%), Theology (11.4%), and Business (12.0%). The results indicated that work experience enhances competencies in using digital devices.

4.4.1 Learning Material Accessibility

The study found a favourable association between the integration of technology, digital devices, and digital learning materials and increased accessibility of learning resources for Tanzanian higher education students. The majority of students have reported having expanded access to educational materials, such as e-books, online platforms, and multimedia content. This has contributed to a more inclusive and adaptable learning experience. The revelation that digital devices serve as gateways to greater accessibility for Tanzanian students enrolled in higher education is at the center of ongoing conversations. Students are given unrestricted access to a wide variety of instructional tools, as highlighted by research on technology's transformative power. This newly discovered accessibility makes a substantial contribution to the development of an inclusive learning environment by removing conventional barriers that have prevented access to knowledge.

Table 3

Learning Materials Accessibility

Device Type	Frequency	Percent
Smartphone	147	40.9
Tablet	68	18.9
Computer	103	28.7
iPad	21	5.8
Other Devices	11	3.1
None of the devices	9	2.5
Total	359	100.0

Table 3 above shows that approximately 40.9% of students in the selected sample have access to digital learning materials via smartphones, while the remaining students have access to other materials.

4.4.2 Challenges Faced by Tanzanian Higher Education Students

Various obstacles have been recognized, despite digital devices showing promise in improving the accessibility of learning materials. There was a considerable obstacle in the form of financial constraints among students, which significantly restricted their access to critical learning materials (Cerezo et al., 2017; Limniou, 2021; Nanjundaswamy, 2021). In addition, the reliance on traditional hardcopy materials made it difficult to adapt to the

increasingly dynamic and interactive resources available online. The debates, on the other hand, do not overlook the challenges associated with implementing digital devices in Tanzanian higher education. A number of issues, including inadequate infrastructure, disparities in access, and the essential need for thorough training for both instructors and students, have come to light as challenges requiring careful consideration. Addressing these challenges becomes crucial for the successful integration of technology into the educational fabric.

Table 4

Challenges Faced by Tanzanian Higher Education Students

Challenge		Frequency	Percent	Cumulative frequency
Valid	Poor internet connectivity	38	10.6	38
	Limited digital literacy	21	5.8	59
	Lack of devices/access	13	3.6	72
	Reliance on hardcopy materials to avoid distractions (social media, games, etc.)	264	73.5	336
	Lack of digital resources for my field of study	17	4.7	353
	Other challenge	6	1.7	359
		359	100.0	
Total		**359**	**100.0**	

Table 4 above shows that about 73.5% of the students have a big challenge of higher reliance on traditional hardcopy materials for learning to avoid distractions (social media, games) rather than other challenges.

4.4.3 Attitudes and Impacts on the Use of Digital Devices for Learning

Students exhibited varied attitudes toward the use of digital devices. Positive attitudes were associated with improved accessibility, engagement, and overall educational outcomes. However, concerns about digital literacy and technological barriers were identified as factors influencing attitudes toward digital device integration. The scope of the discussions extends beyond the immediate findings to contemplate the broader implications for the Tanzanian education system. The integration of digital devices is not viewed in isolation but as a potential catalyst for systemic changes. Considerations on curriculum development, teacher training, and policy adjustments come to the forefront as the discussions prompt a reevaluation of the educational framework to align with the evolving landscape.

Table 5

Altitudes on the Use of Digital Devices for Learning

Altitude		Frequency	Percent	Cumulative frequency
Valid	Global connectivity (positively)	193	53.8	193
	Flexibility in Learning (positively)	78	21.7	271
	Technological overdependence	67	18.7	338
	Lack of privacy	12	3.3	350
	Technological anxiety	9	2.5	359
	Total	**359**	**100.0**	
Missing	System	0	0.0	
Total		**359**	**100.0**	

The findings above show that about 53.8% of the students have positive attitudes toward the use of digital devices for Learning and global connectivity.

Table 6

Extent of Improvement due to the use of Digital Devices

Impact		Frequency	Percent	Cumulative frequency
Valid	Significantly improved	189	52.6	189
	Somewhat improved	102	28.4	291
	No impact	23	6.4	314
	Somewhat worsened	27	7.5	341
	Significantly worsened	18	5.0	359
	Total	**359**	**100.0**	
Missing	System	0	0.0	
Total		**359**	**100.0**	

The findings in Table 5 indicate that the use of digital devices has generally had a positive impact on students' academic performance. Over half of the respondents (52.6%) reported that their performance significantly improved, while 28.4% noted a somewhat improvement. A small percentage (6.4%) experienced no impact. However, some students reported negative effects, with 7.5% stating their performance somewhat worsened and 5.0% experiencing a significant decline.

4.5 Student Experience

The overall student experience was positively influenced by the integration of digital devices. Students reported increased engagement, interactive learning experiences, and the convenience of accessing educational materials at their fingertips. However, the need for targeted interventions to address digital literacy gaps was highlighted to further enhance the student experience. A pivotal aspect of the discourse revolves around the positive influence of digital devices on student engagement and experience. The findings underscore the role of technology-facilitated interactive learning experiences in elevating student interest and active participation. This dimension of the study underscores the potential of technology to transform conventional classrooms into dynamic, engaging spaces that resonate with students' evolving needs.

Table 7

Student Experience on the Use of Digital Devices for Learning

Experience		**Frequency**	**Percent**
Valid	Not Experienced	16	4.5
	Below 1 year of experience	79	22.0
	Below 1 to 3 years of experience	183	51.0
	More than 3 years of experience	81	22.6
Total		**359**	**100.0**

These findings can also be presented in a pie chart as shown below;

The findings above showed that about 51% of the students in the selected sample have 1 to 3 years of experience using digital devices for learning.

Table 8

Type of Improvement

Type of Improvement		**Frequency**	**Percent**	**Cumulative Percent**
Valid	Better internet connectivity	102	28.4	102
	More digital resources (e-books, online platforms)	87	24.2	189
	Training programs for digital literacy	75	20.9	264
	Better quality/availability of devices	92	25.6	356
	Other (please specify)	3	0.8	359
Total		**359**	**100.0**	

The findings in Table 8 indicate that the most frequently suggested improvement for enhancing access to learning materials is better internet connectivity, reported by 28.4% of respondents. This is followed closely by improved quality and availability of digital devices (25.6%) and increased access to digital resources such as e-books and online platforms (24.2%). Additionally, 20.9% of respondents emphasized the need for training programs to enhance digital literacy. Only a small proportion (0.8%) suggested other forms of improvement.

Table 9

Statistics for the Findings Above

Statistic		Digital Devices and Their Usage	Challenges Faced in Using Digital Devices	Altitudes on the Use of Digital Devices	The impact on academic performance	Student Experience on the Use of Digital Devices
N	Valid	359	359	359	359	359
	Missing	2	2	2	2	2
Mean		2.4250	3.2125	1.9375	1.7000	3.0750
Std. Error of Mean		.13982	.14957	.12993	.10126	.08301
Median		2.4091[a]	3.4091[a]	1.7000[a]	1.5694[a]	3.1343[a]
Mode		3.00	4.00	1.00	1.00	3.00
Std. Deviation		1.25057	1.33780	1.16210	.90568	.74247
Variance		1.564	1.790	1.350	.820	.551
Skewness		.573	-.303	1.266	1.791	-.693
Std. Error of Skewness		.269	.269	.269	.269	.269
Kurtosis		.226	-.874	.917	3.771	.706
Std. Error of Kurtosis		.532	.532	.532	.532	.532
Range		5.00	5.00	4.00	4.00	3.00
Minimum		1.00	1.00	1.00	1.00	1.00
Maximum		6.00	6.00	5.00	5.00	4.00
Sum		194.00	257.00	155.00	136.00	246.00
Percentiles	25	1.3714[b]	2.0435[b]	1.0333[b]	1.0139[b]	2.4364[b]
	50	2.4091	3.4091	1.7000	1.5694	3.1343
	75	3.3500	4.3256	2.6471	2.2500	3.7313

The table below summarizes the findings by presenting statistics on digital devices and their usage, challenges faced in using digital devices, attitudes towards the use of digital devices, the impact on academic performance, and students' experiences with using digital devices.

4.6 Discussion

Tanzanian higher education can increase access to learning materials through digital devices (URT, 2018). Computers provide several benefits to students, allowing them to access digital resources such as digital literature, multimedia, online courses, online debates, virtual libraries, and collaborative learning environments. However, limited computer access, weak infrastructure, and electrical issues must be addressed to optimize students' ability to access learning materials. The study also revealed that most students use tablets and smartphones. Tablets enable students to access digital textbooks, educational apps, and multimedia content anywhere, making learning more engaging (Bond & Bergdahl, 2023). However, challenges such as internet connectivity, device compatibility, and digital distractions must be addressed to make cellphones an effective tool for accessible learning. The use of iPads in Tanzanian higher education, for instance, enhances access to study materials due to their functionality, portability, and intuitive interface. iPads provide a variety of educational apps, interactive textbooks, and multimedia tools that encourage personalized and engaging learning experiences (Hodges, 2020; URT, 2018).

Despite these advantages, the use of digital devices for study in Tanzanian higher education remains limited due to poor internet connectivity, which is a major concern among students. Poor connectivity often prevents students from accessing online materials, attending virtual lectures, or interacting online. To address this issue, improvements in infrastructure, expanded internet coverage, the availability of offline educational resources, and student mobile data subsidies are needed. Additionally, a lack of digital literacy among students and staff hinders the effective use of digital devices in higher education. Schools should therefore prioritize digital literacy training programs, workshops, and resources that empower students and staff to use digital devices for educational purposes.

While digital devices are useful, some students are concerned about overusing them. Excessive use of digital devices for learning, research, and assignments may reduce critical thinking, encourage instant gratification, and hinder the development of effective study skills (Schwartz, 2017). Balancing digital and traditional learning approaches is essential to minimize overreliance on technology and promote holistic education. Moreover, student privacy is a significant concern when using digital devices to access educational information, as issues of privacy, surveillance, and security surround internet platforms and educational apps. It is important to prioritize strong data security, transparent privacy policies, and educational programs that enhance understanding of digital privacy rights and best practices for protecting personal information in online learning environments.

Technology in education can also induce anxiety in some students, especially those who are less tech-savvy. The complexity of new platforms or programs may make students apprehensive about adopting digital learning

resources. To alleviate technology-related anxiety, institutions should provide robust technical support, intuitive interfaces, and training programs to help students use digital devices effectively. While some students embrace technology to enhance their education, others remain apprehensive due to unfamiliarity or dependence (Das et al., 2015; Xu et al., 2024). Research shows that digital devices can improve student motivation, engagement, and performance. Digital platforms enable tailored learning experiences, making education more inclusive and effective than purely traditional methods.

The use of digital devices also boosts educational engagement by allowing students to interact with multimedia, virtual labs, and online discussion forums, which enhance learning and promote teamwork, critical thinking, and problem-solving. However, some students struggle with technology or feel overwhelmed by the volume of online information. Providing support to help students navigate digital learning environments can improve academic performance (Swales & Christine, 2004). Digital devices also allow students to customize their learning experiences, access instructional tools at their own pace, review content, and explore areas of interest. Flexible learning platforms can tailor course content and assessments to individual performance and goals, encouraging mastery and self-directed learning. It is important to consider students' backgrounds, learning styles, and technological abilities in order to personalize digital learning experiences. Institutions must promote inclusive design and support services to meet the diverse needs of students.

Although digitization enhances education, students still face challenges that hamper their learning experiences. Device issues, software problems, and internet failures can delay instruction and cause frustration. Data privacy concerns, digital distractions, and misuse of technology may also deter students from using digital learning tools. To support learning, strategies should include technical solutions, educational interventions, user training, and policy formulation.

Access to digital instructional resources in Tanzanian higher education requires a multifaceted approach. Targeted investments in infrastructure will improve internet connectivity and empower students with affordable, reliable digital devices. Building digital literacy and integrating technology into education requires capacity building for both educators and students. Collaboration among educational institutions, government agencies, and the private sector is essential to promote accessibility and ensure equal educational opportunities for all students, regardless of socioeconomic status or ability.

V. CONCLUSION & RECOMMENDATIONS

5.1 Conclusion

Overall, this research illuminates the complex dynamics of using digital devices to improve access to learning materials in Tanzanian higher education. Technological integration can improve accessibility and student experiences, but financial and digital literacy issues must be addressed. The study found that 45% of students in the sample use smartphones to access digital materials, while the rest use other devices. About 36% of students overuse hardcopy study materials, while the rest face additional issues. About 75% of students have positive attitudes toward digital devices for learning and global networking, whereas 25% have negative attitudes. About 56% of students have used digital gadgets for learning for 3 years.

5.2 Recommendation

To maximize the use of digital devices in education, several issues must be addressed. Policymakers and educators should work together to promote digital literacy and equal access to digital resources. To ensure that all students benefit from educational technology, the digital divide must be bridged, especially in financially disadvantaged areas. This research adds useful insights to the ongoing conversation on the integration of digital devices in education, presenting practical recommendations to better the learning experience for Tanzanian Higher students. Continuous assessment and adaptation of educational practices will be necessary to meet students' evolving needs in the digital age. According to the study's findings, the government of Tanzania should strongly consider strengthening information and communication technology (ICT) infrastructure in its public institutions and equipping universities with more ICT workers. It is recommended that students make excellent use of the resources available to them at their respective educational institutions. University partnerships with professional certification information and communication technology companies are required worldwide.

REFERENCES

Bond, M., & Bergdahl, N. (2023). Student engagement in open, distance, and digital education. In O. Zawacki-Richter & I. Jung (Eds.), *Handbook of open, distance and digital education*. Springer, Singapore. https://doi.org/10.1007/978-981-19-2080-6_79

Cerezo, R., Esteban, M., Sánchez-Santillán, M., & Núñez, J. C. (2017). Examines procrastination in computer-based learning to forecast performance: A case study using Moodle. *Frontiers in Psychology, 8*, 1–11. https://doi.org/10.3389/fpsyg.2017.01403

Collis, J., & Hussey, R. (2013). *Business research: A practical guide for undergraduate and postgraduate students*. Macmillan International Higher Education.

Das, S., Dey, A., Pal, A., & Roy, N. (2015). Applications of artificial intelligence in machine learning: Review and prospect. *International Journal of Computer Applications, 115*(9), 31–41. https://doi.org/10.5120/20182-2402

Elfeky, A. I., & Masadeh, T. S. (2016). The effect of mobile learning on students' achievement and conversational skills. *International Journal of Higher Education, 5*(3), 20–31.

Haleem, A., Avaid, M., Qadri, M. A., & Suman, R. (2022). Understanding the role of digital technologies in education: A review. *Sustainable Operations and Computers, 3*, 275–285. https://doi.org/10.1016/j.susoc.2022.05.004

Heding, T., Knudtzen, C. F., & Bjerre, M. (2020). *Brand management: Mastering research, theory and practice*. Routledge.

Higgins, K., & Bushell, S. (2018). The effects on the student-teacher relationship in a one-to-one technology classroom. *Education and Information Technologies, 23*(3), 1069–1089. https://doi.org/10.1007/s10639-017-9648-4

Hodges, L. C. (2020). Student engagement in active learning classes. In J. J. Mintzes & E. M. Walter (Eds.), *Active learning in college science: The case for evidence-based practice* (pp. 27–41). Springer Nature Switzerland AG. https://doi.org/10.1007/978-3-030-33600-4_3

Imamoglu, E. (2024). Artificial intelligence and/or machine learning algorithms in microalgae bioprocesses. *Bioengineering, 11*(11), 1143. https://doi.org/10.3390/bioengineering11111143

Islam, S., & Jahan, N. (2018). Digitalization and education system: A survey. *International Journal of Computer Science and Information Security, 16*, 70–73.

Kaur, R. (2017). Employee retention models and factors affecting employee retention in IT companies. *International Journal of Business Administration and Management, 7*, 161–174.

Limniou, M. (2021). The effect of digital device usage on student academic performance: A case study. *Education Sciences, 11*, 121. https://doi.org/10.3390/educsci11030121

Nanjundaswamy, C. (2021). Digital pedagogy for sustainable learning. *Shanlax International Journal of Education, 9*(3), 179–185. https://doi.org/10.34293/education.v9i3.3881

Naveh, G., & Shelef, A. (2021). Analyzing attitudes of students toward the use of technology for learning: Simplicity is the key to successful implementation in higher education. *International Journal of Educational Management, 35*(2), 382–393. https://doi.org/10.1108/IJEM-04-2020-0204

Ozden, M. (2018). Digital literacy perceptions of the students in the department of computer technologies, teaching, and Turkish language teaching. *International Journal of Progressive Education, 14*(4), 26–36. https://doi.org/10.29329/ijpe.2018.154.3

Perini, M. (2015). Digital tools for learning, engagement, and research: An argument for student affairs and academic libraries. *Global Journal of Human-Social Science: G Linguistics & Education, 15*(12), 9–14.

Ria, T., Khan, M. Z., & De, U. (2024). Students' attitudes towards the use of ICT as a tool for learning: A structural equation modelling (SEM) approach. *SN Social Sciences, 4*. https://doi.org/10.1007/s43545-024-00907-8

Sarfo, J., Debrah, J., Gbordzoe, N. I., & Obeng, P. (2022). Types of sampling methods in human research: Why, when, and how? *European Researcher, 13*, 55–63. https://doi.org/10.13187/er.2022.2.55

Sariyatun, S. N., Abidin, N. F., & Alkmal, A. (2021). The effect of digital learning materials on students' social skills in social studies learning. *International Journal of Instruction, 14*(1), 417–432.

Schwartz, B. (2017). *The paradox of choice: Why more is less* (Revised ed.). HarperCollins.

Seethal, K., & Menaka, B. (2019). Digitalization of education in the 21st century: A boon or bane. In *8th International Conference on Digital Outreach and Future of Management Practices* (pp. 140–143).

Shapiro, S. (2019). Gender disparities in technology: Psychological insights and solutions. *Journal of Educational Psychology, 111*(3), 476–486.

Shenoy, V., & Jhal, N. (2016). Digitalization of Indian educational process: A hope or hype? *IOSR Journal of Business and Management, 18*(3), 131–139.

Swales, J., & Feak, C. B. (2004). *Academic writing for graduate students: Essential skills and tasks* (2nd ed.). University of Michigan Press.

Terras, M. M., & Ramsay, J. (2015). Massive open online courses (MOOCs): Insights and challenges from a psychological perspective. *British Journal of Educational Technology, 46*(3), 472–487. https://doi.org/10.1111/bjet.12274

Timotheou, S., Miliou, O., Dimitriadis, Y., Sobrino, S. V., Giannoutsou, N., Cachia, R., Monés, A. M., & Ioannou, A. (2023). Impacts of digital technologies on education and factors influencing schools' digital capacity and transformation: A literature review. *Education and Information Technologies, 28*(6), 6695–6726. https://doi.org/10.1007/s10639-022-11431-8

Ullah, M., Nardelli, P. H., Wolff, A., & Smolander, K. (2020). Twenty-one key factors to choose an IoT platform: Theoretical framework and its applications. *IEEE Internet of Things Journal, 7*(10), 10111–10119.

United Republic of Tanzania (URT). (2004). *ICT policy for basic education: EMIS, a guide for young managers*. Government Printing.

United Republic of Tanzania (URT). (2018). *Education sector development plan 2016/17–2020/21*. Ministry of Education, Science and Technology. Government Printing.

Venkatesh, V., Morris, M. G., Davis, G. B., & Davis, F. D. (2003). User acceptance of information technology: Toward a unified view. *MIS Quarterly, 27*(3), 425–478. https://doi.org/10.2307/30036540

Xu, P., Wang, J., Jiang, Y., & Gong, X. (2024). Applications of artificial intelligence and machine learning in image processing. *Frontiers in Materials, 11*, 1431179. https://doi.org/10.3389/fmats.2024.1431179

Yamane, T. (1967). *Statistics: An introductory analysis* (2nd ed.). Harper & Row.

Zafer, H. M. I., Maqbool, S., Rong, Y., & Maqbool, S. (2025). Impact of digital learning tools on students' engagement and achievement in middle school science classes. *International Journal of Technology in Education and Science (IJTES), 9*(2), 177–196. https://doi.org/10.46328/ijtes.622

Zrineh, A., Al-Usta, M., & Alwawi, A. (2026). Sampling methods and sample size determination in clinical research: An educational review. *Journal of General and Family Medicine, 27*(1), e70096. https://doi.org/10.1002/jgf2.70096