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Factors Influencing E-learning Adoption when Teaching Science, Technology, Engineering, and Mathematics (STEM) Disciplines at a Science and Technology University in Ethiopia

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Abstract

eLearning technology in Science, Technology, Engineering, and Mathematics (STEM) instruction may positively impact the quality of education in preparing a competent 21st-century workforce in developing countries. Adopting eLearning technology in higher education institutions' STEM departments in developing countries is critical in allowing its graduates to compete in the global workforce. Information technology integration into STEM disciplines in higher education in developing countries may have two purposes: course access and technology skill development. Training this labor force with skills to use eLearning integrated into STEM disciplines increases their technical competencies. However, using eLearning to teach STEM disciplines in higher education institutes in developing countries still needs improvement. Understanding the factors influencing eLearning adoption and use is critical to understanding this phenomenon. This case study explored factors influencing eLearning adoption when teaching STEM disciplines. The study occurred at a mid-sized science and technology university in Ethiopia. A qualitative research approach examined how faculty members describe factors influencing eLearning technology adoption and use in the STEM departments on campus: the data collection method combined semi-structured individual interviews, focused group interviews, and document reviews. Seven faculty members and department heads participated in the personal interviews, and three participated in focus group interviews. An inductive method was used to analyze data collected from participants. Five themes emerged from qualitative data analysis: nature of the course, technology, institution, user's attitude, and environment. Challenges related to technology infrastructure, lack of training and technical support, the course nature, and lack of eCurriculum design were significant factors in adopting and using eLearning. The concerted effort of stakeholders, specifically faculty members, institutional leaders, and technical support teams, to adopt and use eLearning in STEM instruction positively impacts the quality of education in preparing a competent 21st-century workforce in developing countries.

Keywords: e-learning adoption, science, technology, engineering and mathematics (stem), institutional leadership, professional development, 21st century workforce, globalization

1. Introduction

Twenty-first-century careers are unpredictable due to the proliferation of innovative technology, digitalization, and constantly changing information. Thus, historical approaches to education need to be revised to create a future workforce. Preparing students for impending life and work during the rapid innovation revolution is important (Shahroom & Hussin, 2018). However, in low-income countries, preparing a workforce with future-facing competencies may require more adoption of innovative technology. Shahroom and Hussin (2018) explained that future learning requires more customized, hyper-productive, intelligent, portable, worldwide, and virtual technologies. There is a fear of the unknown about the impact that artificial intelligence, automation, and other innovative technologies will influence workers in the future (Nabi, 2019). These careers will require high cognitive skills such as critical thinking, problem-solving, communication, and creativity (Liesa-Orus et al., 2020). A standard four-year degree may not provide the skills of a future workforce that requires knowledge and experience with these technologies.

Garcia-Perez et al. (2021) reported that education oriented toward skill development for the future workforce is critical. Turk et al. (2018) stated that science, technology, engineering, and mathematics (STEM) education prepares students for the world of work, enabling entry into the in-demand careers of tomorrow. STEM fields provide tomorrow's workforce

with skills needed for future jobs. Our rapidly changing society needs highly qualified STEM professionals. As innovation in information communication technologies increases, global adoption and the demand for a workforce trained for the growing digital economy are crucial. Using instructional technologies can play an essential role in addressing this need. The integration of communication technologies in education has led to eLearning, an alternative method to the traditional teaching method limited to time and space (Mahdavinasab et al., 2019). There are many definitions of eLearning. The concept of eLearning in education is related to the evolution of distance learning due to innovations in information communication technologies (ICT). *eLearning* is a technology-mediated learning approach that brings digital transformation to all levels of education (Velverde-Berrocoso et al., 2020). In higher education, eLearning plays a vital role in enhancing the quality of education. Information technology integration into STEM disciplines in higher education in developing countries may have two purposes: course access and technical skill development. For instance, using eLearning technologies to deliver STEM courses will help increase access to these courses and prepare desperately needed individuals who can meet the challenges of today and future work environments.

Information technology has significantly transformed education and content delivery worldwide. The ground-breaking technological advancements and extensive Internet coverage in various parts of the world have changed education delivery strategies. Still, developing countries have not seized the opportunity and the full benefits of eLearning adoption and use (Barclay et al., 2018). Barakabitze et al. (2019) noted that Information Communication Technology (ICT) transforms STEM learning, yet ICT adoption for STEM education remains low in developing countries. According to Barakabitze et al. (2019), the lack of ICT or eLearning adoption and use in educational institutes of developing countries poses a threat to social equality. To remain competitive in leading-edge, information-based, and digitally driven economies, industries hire a highly qualified workforce from around the globe (Garcia-Perez et al., 2021). However, there is a digital divide, a gap between demographics and regions with access to ICT and those with little or no access. Because of this gap, innovation, science, and technology-rich countries will retain employment access for their citizens, but the job opportunities for citizens of developing countries will be limited.

The digital divide creates inequities that make it challenging for developing countries to compete in a global economy. Globalization creates conditions where economic and human capital is prioritized over equality within and across countries (Turk et al., 2018). In developing countries, the technology infrastructure to support educational institutes' effective use of ICT in teaching STEM disciplines is at an infant stage. Barakabitze et al. (2019) stated that STEM education inequities exist among disadvantaged populations due to the lack of eLearning adoption in low-income countries. Decreasing inequities among the underprivileged in developing countries will be critical to expanding accessible technology-enhanced education and preparing a workforce to meet future needs. Garcia-Perez et al. (2021) explained that in the 21st century, competing for future job positions will be difficult for the workforce in developing countries without the knowledge of future job markets and their associated essential skills.

Currently, what is at stake is the growing recognition of the importance of STEM education in developing students' innovation skills for future jobs. Global education policy promotes STEM learning in primary, secondary, and tertiary education to generate innovation and economic prosperity (Ellison & Allen, 2018). Higher education leaders' failure to understand the current trend in globalization and the digital workforce may create a deficit in preparing a productive workforce equipped to contribute to the future economy. Dwivedi and Joshi (2021) explained that higher education leadership needs to promote ICT-integrated pedagogy, staff training, and upgrading of infrastructure. Research shows that the role of ICT or eLearning may boost STEM education. eLearning and STEM education are becoming increasingly important parts of basic literacy in today's knowledge economy (Trybulska, 2019). More broadly, eLearning plays a significant role in preparing a future-ready workforce.

However, eLearning technology adoption needs to be improved in colleges and universities of developing countries in degrees associated with STEM disciplines (Ejiwale, 2013). Makhaya and Ogange (2019) state that due to the lack of adoption and failure to implement eLearning technologies successfully, educational institutes in low-income countries might lag in reaping ICT benefits in modern education. Barakabitze et al. (2019) stated that "ICT is at an embryonic stage in most African countries because both students and teachers require competencies to utilize ICTs in different subjects related to STEM." Lack of competence in ICT use in educational institutes of developing countries adversely affects future workforce development and opportunities. To alleviate the lack of ICT implementation in STEM teaching, Van Nuland et al. (2020) recommended that faculty members design a STEM curriculum that integrates appropriate eLearning tools. Lack of adoption and inadequate eLearning support in education in low-income countries has resulted in inequitable competition for technologically advanced employment opportunities.

This study explored the factors influencing eLearning technology adoption when teaching STEM disciplines. It provides information that may assist institutions in adopting eLearning technology for training in these disciplines.

2. Methods and Materials

An exploratory case study was selected as the qualitative research design. This method requires exploring and understanding a phenomenon using multiple data sources (Rashid et al., 2019). It uses various data collection methods to

confirm the validity of the research process (Yin, 2014). Individualized semi-structured interviews, focus group interviews, and archival document analysis were used for data collection in this study. Faculty members, department heads, and STEM Focus Center Coordinators' perceptions of factors influencing eLearning adoption were explored. Participants were selected using a purposeful sampling method. Benoot et al. (2016) reported that purposeful sampling selects information-rich cases that explain the study's issues.

The criteria for participation in this study were teaching STEM courses, using eLearning technologies, implementing electronic communication mediums in the face-to-face or online classroom, or participating in online course curriculum development approved by department heads. Based on the selection criteria, seven participants volunteered for individual interviews, and three participated in a focus group interview. All participants were professors or faculty members but also held additional positions such as department head or STEM center coordinator. The names used in the study were all pseudonyms. Four participants have doctoral degrees, and three have master's degrees in various engineering specialties, with teaching experiences ranging from four to 30 years. After getting consent to participate in the study from faculty members, department heads, and the STEM Focus Center coordinator, interviews took place in two phases.

In Phase I, the researchers used a semi-structured protocol to interview individual participants. The interviews were based on the general question, "How will STEM department faculty members describe the factors influencing eLearning technologies adoption when teaching STEM disciplines?" The query explored faculty members' views on factors influencing eLearning adoption and use. Interviews revealed factors influencing eLearning adoption, participants' thoughts, perceptions, and beliefs and described new determinant factors in ICT adoption. The combination of three validated conceptual models and frameworks guided the individual interview. These were the Technology Acceptance Model (TAM), Technology, Organization, and Environment (TOE) framework, and Diffusion of Innovation (DOI) theory. The use of a combination of models helps to answer a research problem from various angles (Bhardwaj et al., 2021). The extent of innovation diffusion is not uniform in developed and developing countries. El-Masiri and Tarhini (2017) argued that models and theory of information systems (IS) research initiated in developed countries might not consider developing countries' context. For instance, social value increased eLearning adoption in developing countries, whereas there is no influence in developed countries. Social value indicates the degree to which an individual perceives that it is important that others believe they should use the new system (El-Masiri & Tarhini, 2017). The same factor shows different influences depending on the country's context, including culture, language, and income level. This suggests that developing countries must explore contextual and course design-related factors (Aldowah et al., 2019). Therefore, integrating the conceptual frameworks and models explained and supported the study's purpose and questions and was an appropriate choice as the framework for this study.

The interview protocol for Phase II, the focus group interviews, was prepared based on the analysis results of Phase I. The focus group interview aimed to find the factors influencing eLearning adoption that corroborated individual interview results. Focus groups complement other data collection methods for providing in-depth information in a relatively short period (Gundumogula, 2020). The researcher prepared semi-structured interview questions to learn the participants' views on eLearning technologies. The questions pertain to the participant's experience with technology and attitude toward using it, the ease or difficulty of use, motivation, skills, and any external and internal influencing factors on eLearning adoption and use. The participants reflected on what prompted their use of eLearning technology or deterred eLearning adoption when teaching STEM disciplines.

Archival or public document analysis was the last data collection method to support the results of phases I and II. The analysis of photographs, video, and PowerPoint from the University website on eLearning and brochures from the STEM Department Focus Center corroborated with interview data providing factors influencing eLearning adoption. During document analysis, words and phrases that fit the use of eLearning when teaching STEM disciplines and factors influencing eLearning adoption were identified. For instance, the lack of accessibility is vivid when many faculty members use one ICT-equipped classroom with an overcrowded schedule. In this context, access and infrastructure determine the adoption of eLearning because the availability of classrooms for each STEM department facilitates the ease of using eLearning. Photographs and video clips from the University website and a brochure on project activities from the STEM Focus Center that could explain the use of eLearning in STEM instruction were examined—data analysis from the artifacts focused on emergent data supporting the individual or focus group interviews. The results show that the use of ICT in the STEM department is still at an infant stage in using eLearning technology. Comparing various data sources helped to identify the similarities and differences between each. Triangulating data from these artifacts with individualized focus group interviews increased data credibility. Wood et al. (2020) stated that during document analysis, words or phrases that fit the research purpose and related to the central research question corroborate other data collection methods. The data were analyzed and interpreted to elicit meaning, gain understanding, and develop knowledge. Figure 1 depicts a data collection plan.
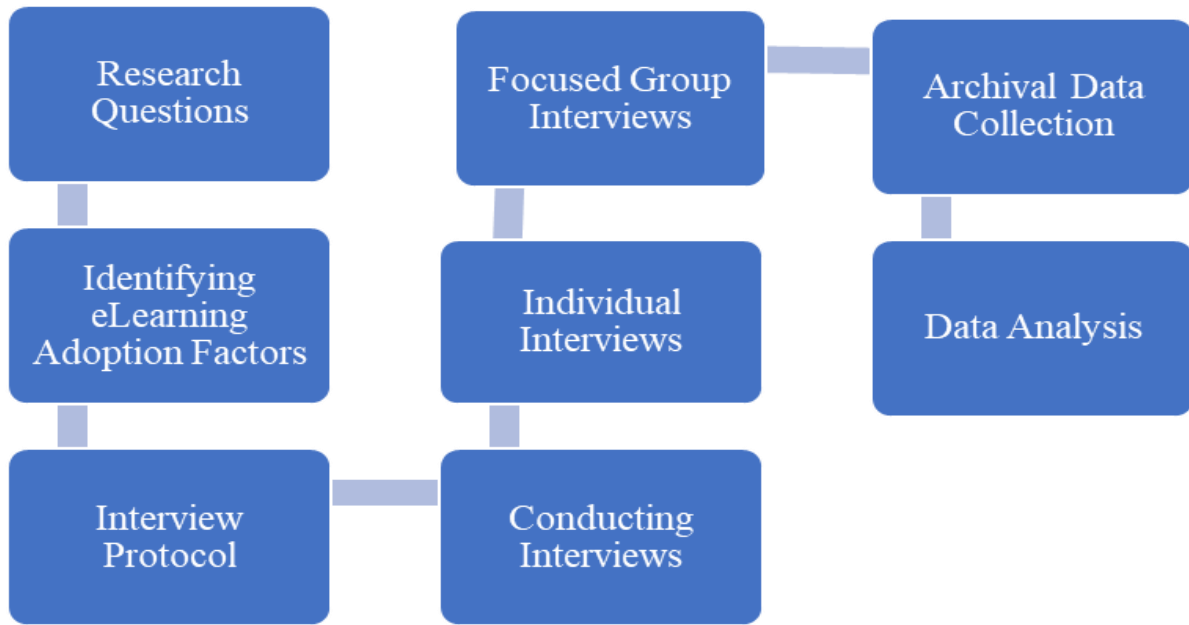
Figure 1. Data Collection Plan

A coding process was employed in this study to perform inductive analysis. Coding in qualitative research comprises processes that enable data to be assembled, categorized, and thematically stored, providing an organized platform for constructing meaning (Saldana, 2013). All three data collection forms assigned a word or phrase (a concept) that best represents the relevant information to the raw data. The two coding processes employed were primary (structural) coding and second cycle (focused) coding. Structural coding identified the data essential to answer the research questions. Data were re-organized and re-analyzed using the first cycle coding method. Focused coding helped develop patterns by identifying coded or categorized data based on thematic or conceptual similarity. All data were transcribed, organized, and coded manually. The coded data were categorized and then conceptualized into themes. The conceptualization of themes prepared the way to answer the research questions and integrate them with theoretical samples. Figure 2 shows schematic features of first and second-cycle coding.
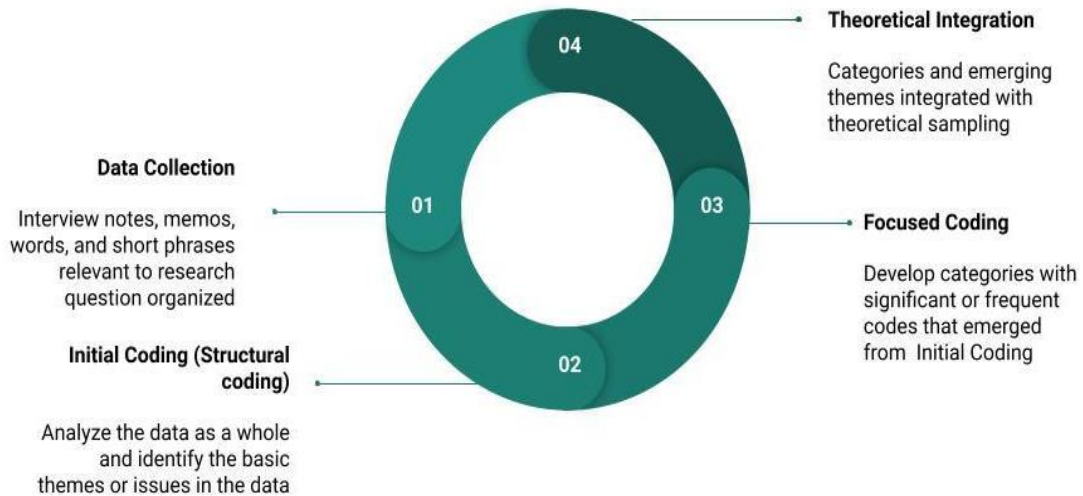
Figure 2. Schematic Features of First and Second Cycle Coding

The codes and emerging themes were described and integrated with the theoretical framework. The description in this theoretical framework helps to identify themes and codes in the findings related to literature. Table 1 shows the frameworks of the coding analysis.

Table 1. Framework for Coding Analysis

Theme	Code	Description
Technology	Access	Availability to users whenever needed
	Infrastructure	Hardware, software, support system
	eCurriculum design	eLearning curriculum is relevant to objectives, teaching methods, assessments, and self-paced learning.
	Nature of course	eLearning tool, activity, student-centered or interactivity
Organization	Top management support	Willingness to use eLearning and support users.
		Technical, cost, speed, performance improvement
	Skilled human resource	Skilled professionals to provide support
Attitude of Faculty members	Internal & External factors	Motivation, lack of skill, incentive, access, training, and qualification
	Perceived ease of use	When respondents mention that e-learning is easy to use or without difficulty
	Usefulness	A belief in one's capability to practice eLearning
Environment	Government policy	Supported by rules and regulations, the ICT policy
	Competitiveness	Competing with other institutions
	Globalization & Foreign Aid	Access to information worldwide, foreign or international aid

3. Results and Discussion

The study looked for factors influencing eLearning use and adoption in a higher education institute of a developing country when teaching STEM disciplines. Several categories emerged from three data collection methods. The data analysis from these sources created five significant categories: technology, eCurriculum, and course content, organization, individual attitudes, and environment. Figure 2 shows the analytical framework for the factors influencing eLearning adoption in a developing country's institute of higher education.
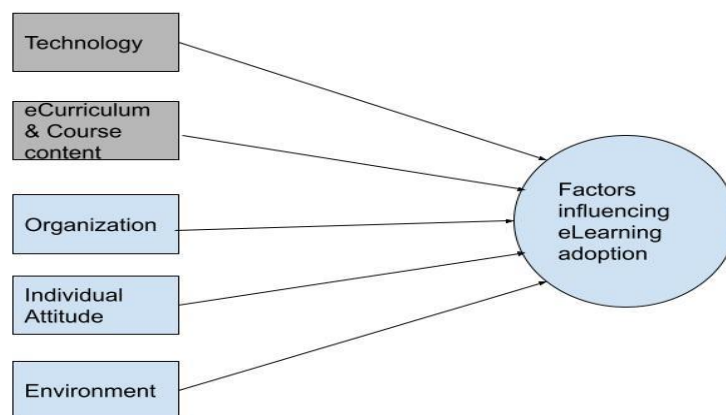

Figure 3. An analytical framework for the factors influencing eLearning adoption

3.1 Technology

Under the technology category, factors attributing to the eLearning adoption in the STEM departments of higher education in a developing country were explained. The eLearning adoption influencing factors were related to the availability of

appropriate technology with the necessary support. The most prominent influencing factors in technology were compatibility, technical support, infrastructure, access, and eLearning standards. Various research findings show that compatibility influences eLearning use and adoption. Researchers defined compatibility as how innovation coincides with the adopter's prior experience or existing value (Rad et al., 2018). Hazelman (2017) explained that eLearning is compatible when it meets instructors' pedagogical practices. The use of eLearning changes the teaching-learning environment. Therefore, compatibility influences the adoption of the new environment (Chong & Olesen, 2017). The compatibility of technology influences the teaching-learning experience and management, and policymakers. Adopting innovative technology is cumbersome due to cost and budget constraints (Alghushami et al., 2020). The use of recent technology that is compatible with the previous or obsolete one is preferred.

This study confirmed that compatibility is influential in adopting and using eLearning. "… technology is unimportant if it does not work with various operating systems" (B. Yaya, personal communications, August 12, 2021).

Technical support is critical in the implementation of innovative technology. The adoption and use of eLearning in institutes of higher education involves more than technical support. Faculty members need help with various aspects of their role during the implementation of eLearning (Hadullo et al., 2018). Institutional support for resource supply, technology expert support through technical aspects, including troubleshooting technical issues, selecting appropriate technology tools, creating accessible media such as audio-visual resources, and pedagogical support to integrate technology with the curriculum is critical. The support must incorporate various stakeholders; hence, collaboration is essential (Scoppio & Luyt, 2017). This study pinpointed the need for support to succeed in eLearning adoption and use. When asked about the attribute of technical support, participants said, "… the availability of software or hardware and classrooms equipped with computers connected to the Internet may not fulfill the required implementation of eLearning in teaching; technical support is essential" (B. Yaya, personal communications, August 12, 2021).

Infrastructure is the backbone of eLearning technology adoption and use. Taurus et al. (2015) described that the infrastructure influences the adoption and implementation of eLearning in higher education in developing countries. Due to low infrastructure development, eLearning in the institutes of higher education in developing countries needs to be improved (Mwakyusa & Mwalyagile, 2016). Although many challenges are associated with eLearning adoption, the infrastructure influences many aspects. The expansion of information technology, inadequate infrastructure, low bandwidth, obsolete technologies due to increased cost of updating, and unreliable electricity are frequently mentioned impediments. This study identified that the underdevelopment of infrastructure negatively influenced eLearning adoption. Participants in this study affirmed what is found in the literature. "… if the technology infrastructure is poor or unavailable, it limits eLearning adoption" (B. Yaya, personal communications, August 12, 2021). Mwakyusa and Mwalyagile (2016) briefly discussed that ICT infrastructure is the most decisive factor in eLearning adoption and impedes other factors such as technology access, lack of skill, and loss of interest in using eLearning resistance to change.

3.2 eCurriculum and Course Content

One of the most significant findings of this study was revealed when the eLearning adoption was discussed concerning electronic learning curriculum or eCurriculum. Curriculum design challenges appear when the traditional methods are applied to the eLearning environment (Aldowah et al., 2019). Research shows that faculty members should know how eLearning course design influences the teaching-learning experience. Aldowah et al. (2019) described that a lack of expertise in eCurriculum design discourages faculty's eLearning adoption and use. eCurriculum design or eLearning course design is vital for the success of eLearning. Research shows that the successful implementation of eLearning can be determined by eCurriculum design, pedagogical methods used, course content, and learning activities (Anderson & Gronlund, 2009). Another study also pointed out that universities in developing countries were unsuccessful in eLearning adoption and implementation because they applied the same policies and strategies as conventional face-to-face teaching and learning (Makhaya & Ogange, 2019). Due to rapid change in science and technology, the pedagogical aspects need revision accordingly. De and Arguello (2020) stated that "despite the rapid evolution of STEM disciplines, the pedagogical approaches in these disciplines are not changing." The transition from using a face-to-face classroom to virtual or eLearning requires careful consideration of the pedagogical approach.

eCurriculum for an online class or eLearning requires revising the learning theory and implementing instructional technology. Due to innovations in technology, a change in the traditional approach to teaching and learning is inevitable. Livingstone (2019) described that the designed curriculum must entail interaction and communication, collaboration, independence, and learner autonomy when using eLearning in a virtual environment. This study highlighted the importance of a new course design for eLearning apart from the traditional form. Participants mentioned that "… all the courses we deliver now are designed traditionally…." (K. Goitom, personal communications, August 16, 2021). The study participants highlighted the need for a curriculum matching available instructional technologies. Another participant discussed, "… eLearning tools should be aligned with the curriculum [and] promote student-centered learning. Contents for student-centered [learning] are interactive in which learners with different learning styles can engage actively" (K. Girma, personal communications, August 21, 2021). Livingstone (2019) mentioned that constructivism and connectivism learning models strongly support the eLearning-based curriculum.

Designing an eCurriculum has a significant effect on engineering and physical science courses. The literature identified factors such as practical laboratory work differently in eLearning implementation (Van Nuland et al., 2020). For times such as the COVID-19 pandemic, teaching using the virtual lab, eCurriculum design is critical. Using a virtual laboratory lacks hands-on experience but helps students understand concepts without risking hazards from chemical interaction. Careful electronic or eCurriculum design is necessary to make a virtual laboratory useful (Eljack et al., 2020). STEM disciplines such as organic chemistry virtual labs need eCurriculum design to present interactive chemistry games that retain learned materials. In this study, participants identified that traditional curriculum designing methods did not align with eLearning adoption and use. Dr. Goitom mentioned, "…due to lack of skill in eCurriculum design, all the courses we deliver now are designed traditionally" (K. Goitom, personal communications, August 16, 2021). Research supplemented the participants' view: "… given the lack of face-to-face engagement, and weekly class times to motivate students and set their learning pace, online subjects need to be designed and developed differently from face-to-face subjects" (De & Arguello, 2020). Effective instructional strategies and online course design for STEM courses increase learning. The literature supported the study findings on eCurriculum design.

A unique finding in this study was the need for standards for eLearning influences, adoption, and use. Institutes of higher education have guidelines and expectations for faculty members. The implementation of eLearning requires specific guidelines and standards. These standards could ensure educational quality. Research shows that a significant challenge to quality assurance in education is the need for standards (Agrawal & Mittal, 2018). Ketema and Nirmala (2015) pointed out that the instructional process, method, student assessment, and support measure eLearning quality and standards. Prasad (2016) also discussed that two eLearning standards are courseware and technical standards for successful eLearning adoption and use. This study found the paradox between the information in research and the practice on the ground. For instance, one of the participants criticized the lack of standards in the eLearning implementation on campus.

Participants stated, "… the faculty members' uploading the video lectures and notes does not replace eLearning's design and technical standards requirement" (K. Girma, personal communication, August 21, 2021). Another participant pointed out that the eLearning implementation strategy changed with a change in funding agencies. "… depending on foreign aid, the implementation of eLearning, the eCurriculum design, and standards changed periodically" (L. Hailu, personal communication, August 17, 2021). Despite various constraints, eLearning and training industries suggested that higher education institutes have courseware design and technical standards. Prasad (2016) reported that courseware standards include instructional design, visual design, media, and assessment design, whereas technical standards refer to the interoperability and portability of eLearning courses across browsers and platforms.

Research on eLearning or ICT implementation in the institutes of higher education in developing countries shows that the nature of courses influences eLearning adoption and use. Due to variations in course type, integrating eLearning technology into the curriculum is daunting (Van Nuland et al., 2020). Rapid changes in science and technology outdated the old method of teaching-learning. De and Arguello (2020) mentioned, "unlike history or philosophy, the STEM landscape is undergoing continuous and rapid changes." Developing an eLearning course requires identifying and organizing course content and defining instructional media, delivery strategy, and assessment methods. The nature of the course influences the media, the strategy used, and the evaluation process. Van Nuland et al. (2020) described that for the eLearning implementation, choosing the technology tool depends on the cognitive level specific to the learning objectives and understanding and mastery of the contents. A course design is closely related to the nature of the system. Previous studies show that course design influences eLearning adoption and use (Aldowah et al., 2019). This study found two opposing opinions from the participants. For instance, the optical fiber communication professor explained the comfortability of using eLearning. However, some participants described the difficulty in use due to the nature of some courses: "…I suggest advanced technology use. Contents in the STEM discipline require technology tools with various user requirements" (L. Hailu, personal communication, August 17, 2021).

Another participant added, "I do not believe it can demonstrate laboratory classes using eLearning tools. Students lack practical skills" (K. Girma, personal communication, August 21, 2021). Developing a negative attitude toward eLearning for specific courses rejected eLearning adoption and use. Contrary to the findings, research shows that many interactive eLearning tools facilitate teaching-learning of complex content. Van Nuland et al. (2020) cited the 3D Interactive Anatomy electronic tool, a three-dimensional appearance that provides high user interactivity. Razali (2015) added that the advancement in software and communication technologies offers remote laboratory (eLaboratory) classes at less cost than a hands-on laboratory. Proper curriculum design uses technology tools to increase students' understanding of abstract concepts. Chiu and Linn (2014) explained that an inquiry-oriented online curriculum design uses dynamic molecular visualizations to improve students' experience of chemical reactions.

3.3 Organization

Top management, human resource skills, and efficiency and effectiveness were discussed under the organization category. The university's top management, human resource skills that provide technical support, and the efficiency of the support teams were attributes of eLearning adoption on the campus. The top management plays a vital role in eLearning adoption, including adopting policy frameworks, providing leadership support, budget allocations for professional development,

setting standards, and strategic planning. Dwivedi and Joshi (2019) discussed that top management is characterized by making decisions that improve the performance of faculty members of higher education institutions. The study participants agreed on the role played by top management. They stated that their support is often detrimental, in their experience, to building Internet infrastructure and training human resources (G. Hirpha, personal communications, August 12, 2021.) Research findings supported the participants' opinions. Al-Maroof et al. (2021) reported that institutional support, which is top management support, is the backbone of eLearning adoption. In this study's context, although the institute of higher education plays a monumental role in eLearning adoption, there is often a lack of support from upper management. A lack of training mentioned by participants confirmed the insufficient support from top management. A participant stated that our top management encouraged using eLearning technology, but motivating words were not enough. Incentives [are] needed for faculty members (B. Gamachis, personal communication, August 14, 2021).

This study emphasized that human resource skills contribute to eLearning adoption and implementation. Human resource skill in the study's context pertains to the professionalism of the technical support team. Skilled supporters lead by demonstrating skills and contributing to creating a healthy and positive work environment for the global future. In other words, with the current traditional modes of teaching and learning, faculty members in a developing country's institutes of higher education cannot prepare a competitive global workforce. Faculty members in the institute of higher education need effective use of eLearning and pedagogical models that would help them acquire digital skills (Linde & Petrova, 2018). The study participants asserted that skilled human resources enable us to use the resources effectively and efficiently (G. Hirpha, personal communication, August 12, 2021). Technical and pedagogical support is critical to increasing higher education's productivity by improving faculty members' performance. Yue (2019) stated that teachers develop instructional strategies to prepare the 21st century workforce through professional development by skilled human resources.

The efficiency and effectiveness that emerged as explanatory attributes had two implications. First, effective use of eLearning or ICT in education minimizes budget deficit. eLearning or ICT use overcomes the issue of cost, lack of teachers, and poor quality of teaching and reduces time and distance barriers (Agrawal & Mittal, 2018). A few skilled faculty members can reach a large population of students. In the context of developing countries, anything that reduces the financial burden is an influential factor in eLearning adoption and use (Alone, 2017). Next, effectiveness was expressed in producing creative, skilled, and problem-solving productive citizens. Wright and Horta (2017) reported that ineffective and inefficient institutes of higher education should have been included in global participation. Dwivedi and Joshi (2021) described that higher education's adoption of eLearning would make the entire economic sector productive. "[The] traditional system of instruction does not help to prepare [a] competent digital workforce, but skilled human resources can support instructors both technically and pedagogically to use ICT in [a] population lacking digital skills (A. Abamacha, personal communication, August 22, 2021)." The statement from the participant signifies effectiveness and efficiency obtained through the support of skilled human resources, agreeing with the literature findings. Chong and Olesen (2017) focused on combining an institution's top management and human resources skills, the most studied influential factors of eLearning adoption, and the driving sources to boost an institution's performance, supporting the study's findings. However, this study's eLearning adoption factors include low efficiency and effectiveness.

3.4 Individual Attitude

Factors related to individual attitudes were identified and classified as internal and external influencers. The internal factors arise from the users who influence the intention to use eLearning, including lack of skills and motivation, perceived ease of use (PEOU), perceived usefulness (PU), and teacher qualifications and training. PU and PEOU were the prominent influencing factors related to individual attitudes in information system adoption (Lazar et al., 2020). Aldowah et al. (2019) discussed that successful eLearning adoption and use could emerge from interrelated factors that impact the faculty's decision to implement eLearning. For instance, motivation relates to the user's internal motive to use or reject innovation. Faculty members' motivation might be anything from boosting performance to personal satisfaction. PU was an internal factor influencing users' attitudes to eLearning.

The external factors were outside the sphere of users but indirectly influenced the adoption of eLearning. Contrary to PU, the research participants did not prioritize ease of use. When asked about the ease or difficulty of eLearning, a participant answered: "It is not the level of difficulty that matters; rather, it's accessibility in our context" (K. Goitom, personal communication, August 16, 2021). Access to Internet infrastructure is an external factor for faculty members to use eLearning, but the presence or absence of it still influences motivation to use innovation.

Accessibility and standardization were found to be external factors influencing individual attitudes. For instance, a faculty member can integrate technology into the curriculum, but students need more Internet infrastructure to access content. The inaccessibility of technology in the remotest village negatively influenced eLearning adoption and use, which eventually resulted from a lack of Internet infrastructure. The importance of interrelated influential factors in eLearning adoption was an exciting study finding.

The literature review identified a lack of skill influencing eLearning adoption and use. Wingo et al. (2017) reported that faculty members' belief in their competence to use technology is low due to a lack of skill. This study identified

participants' significant perceptions influencing their eLearning adoption and use. Faculty members reacted to the influence of the nature of the course on eLearning adoption as follows: "… lack of technical skills on e-learning and e-content development by the teaching staff is a big problem. Bennett's (2014) digital practitioner framework considered skills as the ability to use eLearning as a tool to suit teaching-learning. The faculty members feel uncomfortable using eLearning and need skill development. Yue (2019) suggested that professors develop the necessary skills and instructional strategies to prepare for the 21st-century workforce.

Due to the digitalization of the 21st-century workplace, developing digital skills is mandatory for employees in every economic sector. Dean and East (2019) pointed out that today's job openings are for digitally literate employees who received relevant training. Training is needed to augment the digital skills that various jobs require. Chatty et al. (2018) assessed mechanisms to ensure digital training programs meet the digital literacy training standards. Chatty et al. (2018) discussed that skills certification and recognition or promotion increase eLearning use and adoption.

Due to massive changes in innovative technology across all sectors, a developing country's institute of higher education is exposed to challenging situations. One of the challenges to developing countries is a need for more infrastructure and skills to use available technology. The use of eLearning is becoming a necessity for two tangible reasons. First, from the current reality, the COVID-19 pandemic poses population health threats, resulting in closed educational institutes. Next, online classes or an eLearning environment are becoming an inevitable alternative with increasing enrollments. Davy et al. (2019) discussed the need for a collaborative effort to change face-to-face classes to online or use eLearning.

Access to technology, when needed, promotes the adoption of eLearning. Bennett's (2014) digital practitioner framework states that a reliable Internet connection could increase eLearning use. However, accessibility by itself is not a success factor for adopting innovation. Accessibility of ICT infrastructure and reliable hardware were enablers, not drivers, of the successful adoption of eLearning (Armstrong, 2019). Bennett's digital practitioner framework explains accessibility in terms of networked devices and applications, media devices, people who can support using technology, and a network of people with ideas for using technology (Bennett, 2014). Accessibility was one of the findings of this study. "It is good to provide information and notify my students, but how many of them have access?" (A. Abamacha, personal communication, August 22, 2021). The statement of this participant signifies the demotivating power of inaccessibility.

3.5 Environment

Most importantly, factors attributed to eLearning adoption influence emerged from the environment related to the institution. Environmental factors include government support, foreign aid, cooperation, connecting to the global community, or globalization. Past research findings related numerous factors influencing innovation adoption to the environment category under the TOE framework. Bhardwaj et al. (2021) reported that eLearning influencing factors are market components, competitors, and the regulatory environment. This study contained two influencing factors, competitiveness and government support (regulatory environment). Participants of this study affirmed that the government has policy support for adopting eLearning or ICT implementation, indicating a positive influence on eLearning adoption. Taurus et al. (2015) reported that government support by setting an eLearning policy influences eLearning adoption positively.

Competitiveness is related to the capacity of the institution of higher education to become better than others—the notion of competitiveness links innovativeness and taking rank on an international stage (Yildiz, 2016). Due to globalization in the competitive world, the use and adoption of ICT or eLearning in institutes of higher education are critical. Kristic et al. (2020) reported a strong correlation between higher education and competitiveness of the economy and sustainable development. The idea of competitiveness is reflected in the participants' views, as seen in the statement from one participant: "… I think our university is in a better position than others. That motivates everybody to use eLearning (G. Hirpha, personal communication, August 12, 2021)." Universities that rose above the global competition and internationalized are selected based on the quality of education. Competitiveness in quality education includes the skills of graduates, critical thinking in teaching, public expenditure on higher education, research publications, digital skills, patent applications, and international co-invention (Krstic et al., 2020). Therefore, competitiveness in the global ranking of higher education influences eLearning adoption and use.

This study's findings introduced foreign aid as a factor influencing eLearning adoption. Project aid and financial support were part of multifaceted assistance to educational institutes of higher education in developing countries (Ferry et al., 2021). Due to variations in the contexts of foreign aid recipients, implementation varied. Ferry et al. (2021) reported that the foreign aid funds expanded enrollments in primary education of the recipient country but left a considerable gap between what aid does and what it potentially could achieve with its contribution to educational quality. Ensuring available aid is essential to using the advantage of foreign aid for effective and efficient adoption and use of eLearning. Participants witnessed that the contribution of foreign aid was below expectation in meeting the intended purpose. Since the aid budget may be used for various purposes, institutionalizing foreign aid by capacity development, knowledge transfer, and technical cooperation is essential.

4. Conclusions and Recommendations

Increasing technology-enhanced learning in STEM education is critical to preparing a future workforce that plays a role in

economic and societal well-being. Research shows that teachers' pedagogical beliefs on the use and integration of ICT in teaching STEM subjects are likely to influence their perceptions and practice, whereby negative thoughts may also negatively affect learners' education outcomes. The main factor influencing faculty's eLearning use was lack of skill due to lack of training.

The use and adoption of eLearning has been practiced in higher education because several tools help teach and increase students' learning. eLearning technologies are used to engage students in learning activities by employing various methods of instruction, including discussion, web seminars, online meetings, and collaboration. However, one cannot imagine achieving academic goals without technical support. The study provided areas that need institutions' and faculty members' attention to avoid falling behind more advanced higher education systems and global competition. Document analysis revealed that the most noted eLearning adoption factors were a lack of access and infrastructure. The university failed to provide appropriate ICT resources, including smart classrooms (B. Gamachis, personal communication, August 14, 2021). Lack of technology access adversely affects eLearning adoption and use, extenuating global competitiveness. One of the critical aspects of information communication technology is its ubiquity, which appears everywhere and enables information access from the best practices globally. Scaling up the faculty members' skills by giving them access to prestigious information sources helps address students' needs.

Therefore, connection to the rest of the world will help knowledge sharing and ensure faculty members remain lifelong learners in 21st-century skill development. Another implication for practice is that STEM faculty members and department heads need self-initiated training by creating a personal connection with international higher education institutions. Personal growth based on inherent motivation can take place in wide dimensions. For instance, participating in international online symposiums and workshops helps enhance professionalism, continuous improvement, and collaboration. Global connections initiatives open the door to identifying and understanding innovation issues, taking challenges, and learning opportunities. Sharing information with the international community enables faculty members to be vigilant of the current and future technology trends in teaching-learning.

Finally, for eLearning adoption and implementation in teaching STEM disciplines to increase, faculty members in the STEM departments of the institute of higher education must understand the underlying factors that influence eLearning adoption and implementation:

● Appropriate curriculum design for eLearning; understandable course content using interactive learning activity and multimedia instruction.

● Working jointly with various teams, including subject matter experts (SME), instructional designers (IDs), and ICT personnel.

● Accessible, efficient technology infrastructure with a reliable Internet connection and practical technical support.

● Financial support to motivate, qualify, and train faculty members and support groups. Higher education leadership needs to promote ICT-integrated pedagogy, staff training, and infrastructure upgrades.

● Instructors' attitude toward using eLearning increases eLearning adoption and technological skills development with institutionally financed and self-initiated efforts to join the learners' community.

● Promote global connections to best practices, encourage foreign investors to participate in ICT infrastructure development, and internationalize higher education.

5. Limitations

This study's limitation was using online data collection with frequently interrupted Zoom meetings due to intermittent connection or connection failure. This limitation resulted in a lack of exhaustive data collection, but participants were reached by email for follow-up. Another limitation of this study was that it only researched STEM departments. Due to the study's design, future research is recommended for generalizability. Participants from various departments would have distinct factors influencing eLearning adoption and use.

6. Future Research

This study explored the factors influencing eLearning adoption by interviewing a few department heads and faculty members in STEM departments. First, repeating this study by extending it to departments other than the STEM department and re-examining and comparing it with a multiple case study design would help validate the findings. Second, future studies could advance this research and examine factors influencing eLearning adoption and use from various dimensions, including students, faculty members, institutional management, eCurriculum design and contents, and technology system dimensions on the University campus. Third, this study employed a qualitative single case study with an exploratory design. Future researchers may use different research designs to explore additional eLearning success factors or validate this study's findings. Finally, studying the role of teamwork, including subject matter experts (SME), instructional designers (IDs), and ICT or eLearning experts, could ease the implementation of eLearning in the institutes of higher education when teaching STEM disciplines.

7. Final Conclusions

Various factors influence the use and adoption of eLearning when teaching STEM disciplines in higher education in low-income countries. The institutes of higher education in a developing country may envisage various strategies to adopt and implement eLearning. Failure in technology implementation may lead to the lack of broader access to knowledge and information society and prepare citizens with inadequate skills. The future workforce builds the national economy and plays a part in societal wellbeing. During this age of globalization, where technological innovation drives the knowledge economy, higher education institutions need to produce a workforce contributing to economic development and social well-being. Achieving the preparation of the future workforce through efficient and effective implementation of ICT or eLearning in the teaching-learning process in the STEM disciplines is critical.

To realize the adoption and implementation of technology in teaching STEM education, the following items must be addressed:

1. Assist and encourage faculty members to become involved and take the initiative to connect or tap into innovative technology and information that will help and guide them in implementing technology effectively and efficiently.
2. Providing technical support with ongoing pedagogical improvement strengthens capacity building.
3. Providing financial incentives and a research budget for eLearning adoption led to innovativeness, creating technology beyond consuming diffused innovations.

Top management could develop policies and procedures that help faculty members, institutional leaders, technical support teams, instructional technologists and designers, and donors. The concerted effort of top management, technical support staff, and faculty members would help implement eLearning that uses quality instruction and prepares the workforce with creative thinking, problem-solving, effective communication, and collaboration practices. Faculties and institutions must take the initiative and responsibility for changing innovative technology consumption to create more innovative thinking that takes the country's education quality to the next level of success. That is possible when all stakeholders identify, understand, and pass the hurdles of influencing factors through concerted effort.

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

Data sharing statement

No additional data are available.

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