Factors influencing effective integration of educational technology in the colleges of teacher education in Ethiopia: A constructivist grounded theory

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Integrating educational technology (EdTech) in colleges of teacher education (CTEs) in developing countries presents complex challenges influenced by various factors. In Ethiopia, where research on this subject is limited, these institutions, which play a critical role in preparing future educators, remain unexplored. This study explores the contextual factors affecting teacher educators' EdTech integration and formulates a theoretical framework. Employing constructivist grounded theory, the study was conducted in four Ethiopian CTEs. Data were gathered through semi-structured interviews, structured observations and document analysis, with 23 participants selected via purposive and theoretical sampling. The study identified teacher educator-related and external factors as crucial determinants of EdTech integration. Institutional readiness was a key external factor, while teacher educators' digital competence and readiness to integrate technology were central internal factors. A theoretical framework was co-constructed to illustrate the interplay of these factors and their influence on EdTech integration. It aligns with activity theory and extends the technology acceptance model and the unified theory of acceptance and use of technology. The credibility of the findings was validated through a member-checking survey. The study recommends quantitative research to pinpoint the most predictive factors and to assess the framework's applicability in developing countries.

Implications for practice or policy:
- In developing countries, CTEs should strategically plan and execute professional development programs, align training with UNESCO's ICT competency framework, establish technology infrastructure, facilitate technical support and motivate teacher educators to engage in EdTech initiatives.
- Ministries of education and regional education bureaus should develop and enforce institutional EdTech policy and facilitate EdTech integration into the curriculum.
- Teacher educators should participate in workshops, seminars, and online courses to stay updated with EdTech tools and digital pedagogy.

Keywords: educational technology, teacher education, contextual factors, developing country, Ethiopia, constructivist grounded theory

Introduction

Background

Educational technology (EdTech) leverages information and communication technologies (ICTs) to facilitate personalised, inclusive, and interactive learning experiences (UNESCO, 2023). It also refers to the meaningful use of technology to achieve learning goals (Kimmons et al., 2020). Such technologies are playing a significant role in transforming education by enhancing teaching methods, learning environments and accessibility (Bilyalova et al., 2020; UNESCO, 2023). For example, the disruption caused by the COVID-19 pandemic highlighted the significance of digital technologies in education (Cohen & Cohen, 2023; Rincon-Flores & Santos-Guevara, 2021).

In cognisance of EdTech's impact on enhancing the quality of education, higher education institutions in developed countries have been integrating it into their education system (Wang, 2021). Nonetheless, due to multifaceted factors, most developing countries are still lagging in this regard (Ezumah, 2020, Chapter 4). Studies conducted in African countries, such as Nigeria (Ifinedo et al., 2020), Tanzania (Mtebe et al., 2021), Zimbabwe (Rudhumbu, 2020) and Ghana (Nyagorme et al., 2022), have highlighted the complex nature of these factors. Similarly, a study conducted in Malaysia indicated the existence of several factors impeding EdTech integration (Mat Dangi et al., 2022). Generally, the EdTech literature categorises these factors as internal and external (Cheng et al., 2020). Internal factors stem from teacher educators (TEs), while external factors arise from institutions, technology and the teaching and learning environment.

In Ethiopia, different sporadic attempts are being practised to support EdTech integration in higher education institutions; however, it is not effective (Ferede et al., 2022a). Studies have claimed that EdTech integration into teaching-learning practices is affected by several factors (Ferede et al., 2022a; Turugare & Rudhumbu, 2020). Notably, the absence of concrete models, policies and frameworks was indicated as a reason for such failure (Ferede et al., 2022a; Seifu, 2020). These arguments call for potential research on developing a context-specific EdTech integration framework for developing countries, particularly Ethiopia, that could fill the gap in the literature and practice.

Moreover, research outputs showcasing EdTech integration at colleges of teacher education (CTEs) in developing countries, particularly Ethiopia, are scarce. Only a few of the studies focus on universities (Ferede et al., 2022a; Temesgen et al., 2022). Further, the Ethiopian education development roadmap (2018–2030) underscored the underutilisation of EdTech in CTEs (Teferra et al., 2018). This highlights the need for exploratory research to identify the underlying reasons influencing EdTech integration in CTEs in Ethiopia.

Objectives

This study aimed to develop an EdTech integration framework to address theoretical and practical gaps in developing countries. Specifically, it sought to address the following objectives:
- Explore contextual factors influencing EdTech integration among TEs in Ethiopian CTEs.
- Identify the interplay among the factors and EdTech integration.
- Construct a theoretical framework grounded in empirical data and existing theories.

Methods

The study followed a qualitative research approach to explore TEs' knowledge and insights into the factors affecting EdTech integration (Creswell & Creswell, 2017). Among the qualitative methodologies, our study employed grounded theory (GT; Glaser & Strauss, 1999); hence, the aim was to develop a context-specific EdTech integration theoretical framework. GT is useful in gaining a rich and complex understanding of people's experiences and behaviour. Three GT approaches — classical, interpretivist and constructivist – are widely recognised in the literature (Sebastian, 2019). Classical GT emphasises an objective, emergent theory from data without prior assumptions; interpretivist GT focuses on understanding meanings and social interactions from participants' perspectives; and constructivist GT (CGT) acknowledges the researcher's role in co-constructing knowledge with participants in a context-sensitive manner. Accordingly, CGT was selected for the current study for its flexibility in developing a context-specific theoretical framework (Charmaz, 2014). It involves iterative steps of data collection, coding (initial, focused and theoretical), memo writing, constant comparison, theoretical saturation and theory building. The study was conducted between February and August 2024.

Context and participants

In Ethiopia, there are 39 government CTEs across 12 regional states, governed by their respective regional education bureaus (Ministry of Education, 2023). Four CTEs – Bonga, Hawassa, Hossana and Arba Minch – were selected for representative data. TEs from diverse departments (social and natural sciences,

mathematics, information technology (IT), language, and education) were included to capture varied experiences. Additionally, ICT directors (ICTDs) and academic and research vice deans (ARVDs) were included to triangulate the findings. A total of 23 participants (17 TEs, three ICTDs and three ARVDs) were selected through purposive and theoretical sampling. Aligned with CGT's iterative approach, the study involved seven participants in the first phase, 14 in the second and two in the third.

Demographic information

Among the 17 TEs, three held PhDs and 14 had master's degrees. Their backgrounds included language (4), natural science (4), education (3), mathematics (2), IT (3) and social science (1), with experience ranging from 5 to 25 years. Two ARVDs had master's degrees and 5 years of service, while one had a PhD and 4 years of service. All ICT directors held master's degrees with 1 year of service.

Data collection

Data were collected iteratively using validated and pilot-tested interview protocols. Both face-to-face and online modes (via Zoom, Telegram and WhatsApp) were used. Interviews were recorded and manually transcribed using MAXQDA 2020 software (VERBI Software, 2019). Strategic plan documents and field observations were also analysed to support the findings.

Data analysis

The analysis followed an iterative process, starting with TE1, coding data line by line (initial codes) based on its relevance to the research goal. Through constant comparison, frequently occurring and conceptually related initial codes were grouped into focused codes or categories (using the creative coding function of MAXQDA), with memos capturing reflections on underlying meanings. Saturation of categories was reached at the 14th and 15th TEs, after which core categories were formed by linking related categories. Data from the 16th and 17th TEs did not yield new insights, confirming theoretical saturation. Although theoretical concepts were avoided initially, we acknowledge the influence of our prior knowledge on shaping the theoretical concepts. The analysis, supported by MAXQDA 2020 software (VERBI Software, 2019), concluded with a theoretical framework. Further, a member-checking survey was conducted with 12 TEs to validate the findings. Participants were provided with a list of factors derived from the analysis and asked, "Does this factor reflect your own experiences and opinions?" Responses were recorded as "Yes", "Somewhat" or "No".

Ethical issues

Ethical clearance was obtained from the Jimma University Institute of Technology Ethical Review Board with reference number RPD/JIT/152/16 on January 26, 2024. All participants provided informed consent before their interviews. Pseudonyms were used to ensure the confidentiality and anonymity of participants and their data.

Results

A total of 10 core categories were co-constructed using 30 subcategories that emerged via the CGT data analysis, as shown in Figure 1. These include ICT resource availability and support (resource and support), teacher educator digital competence (digital competence), leadership and institutional readiness (institutional readiness), student digital competence, professional development, technology integration readiness (readiness), teacher educator attitude (attitude), curriculum alignment, simplicity and usefulness of technology (tech usability) and colleague influence. The findings are grounded in verbatim data from interviews, evidence from field observations and strategic plan document analysis.
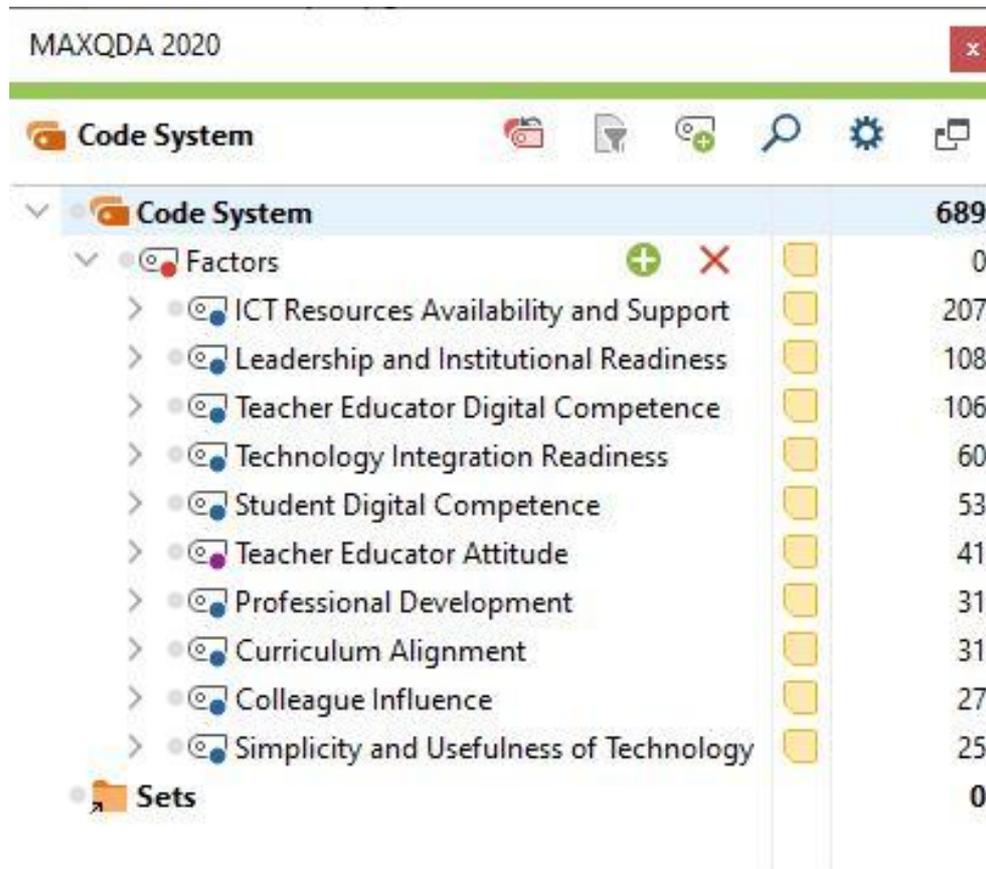
Figure 1. Code system representation of the constructed factors

ICT resource availability and support

This core category represents the availability of technological resources and technical support to promote EdTech integration. As indicated in Table 1, it consists of six subcategories: ICT infrastructure, ICT facility, resource scarcity, budget constraint, access to EdTech and technical support.

Table 1
Subcategories of ICT resource availability and support

Subcategory	Frequency of coded segments	Sample verbatim extracts
ICT infrastructure	58 (28%)	TE13: "Infrastructure, like the network […] is the main factor in pedagogical practices." [Barrier]
ICT facility	45 (21.7%)	TE2: "The facility-related challenges, like internet access and others, […] are affecting the integration of EdTech." [Barrier]
Resource scarcity	42 (20.3%)	TE3: "There is a lack of ample equipment and tools that must be fulfilled to engage teachers." [Barrier]
Budget constraint	26 (12.6%)	TE1: "In science teaching, effective integration of EdTech is very important, but it needs a substantial budget." [Barrier]
Access to EdTech	23 (11.1%)	TE5: "The most challenging issue is the accessibility of educational resources, especially technological devices." [Barrier]
Technical support	13 (6.3%)	TE8: "there are also technical support problems. Hence, a limited number of technicians work in the technology dissemination department." [Barrier]

ICT infrastructure emerged as the principal barrier to EdTech integration, corroborated by interviews, field observations and documents. Participants highlighted insufficient equipment (e.g., TE2 noted unmet tool requirements) and shared malfunctioning computers and scarce resources like printers and projectors (TE5). Field observations and interviews (e.g., TE8 and TE11) confirmed persistent facility gaps, including inadequate IT tools for teachers and students, directly hindering teaching-learning activities. These systemic shortages underscored the critical role of robust infrastructure in enabling effective EdTech integration.

As highlighted in interviews, budget constraints significantly contributed to poor ICT infrastructure and resource limitations in CTEs. Reliant on regional government funding, these institutions struggled with technology integration. An interview with ICTD3 underscored the insufficient budget allocations for ICT infrastructure development.

Access to EdTech remains a key barrier to technology integration, particularly for students. TE12 noted that shortage of devices like smartphones and computers are hindering resource sharing (e.g., course materials, exercises). Additionally, many TEs cited insufficient technical support for maintaining and troubleshooting tools as a challenge for EdTech integration (e.g., TE3, TE5, TE8, TE10 and TE13).

TE digital competence

As presented in Table 2, this core category represents the teacher's technology knowledge, digital skills and experience. Three concepts were predominantly related to technology knowledge as a determining factor for effective EdTech integration. These include a lack of technology knowledge, technological pedagogical content knowledge (Mishra & Koehler, 2006) and knowledge of EdTech integration.

Table 2
Subcategories of teacher-educator digital competence

Subcategory	Frequency of coded segments	Sample verbatim extracts
Technology knowledge	62 (58.5%)	TE2: "Due to lack of knowledge, I cannot effectively integrate EdTech into my lessons." [Barrier]
Digital skills	29 (27.4%)	TE11: "Lack of skill may not encourage to incorporate EdTech into the teaching-learning process." [Barrier]
Experience	15 (14.1%)	TE3: "Due to the lack of experience and exposure, I did not use it most of the time." [Barrier]

Most participants (e.g., TE2, TE3, TE5, TE11, TE13, TE14 and TE15) boldly indicated the effect of a lack of technology knowledge on their ability and decision to integrate technologies. As evident from TE9, if a teacher delivers lessons integrating content, pedagogy and technology knowledge, then the learning objectives can be addressed. Most TEs reported that they lack digital skills, though it plays a significant role in addressing the demands of 21st-century education. Experience was another factor that affected TEs' competence in integrating technology. Even though teachers believe in the importance of technology, due to a lack of experience, they fail during integration (TE3). Overall, the findings highlighted the significant role of TEs' digital competence in effectively integrating EdTech.

Leadership and institutional readiness

This core category reflects the overarching theme that unites qualities of leadership, institutional vision, and plans to promote effective EdTech integration. As indicated in Table 3, it included leadership commitment, support, perception, attitude and institutional vision and plan.

Table 3
Subcategories of leadership and institutional readiness

Subcategory	Frequency of coded segments	Sample verbatim extracts
Leadership commitment	32 (29.6%)	TE4: "The college has a good and positive attitude, and trying to bring some technological materials." [Driver] TE5: "The leadership commitment is the other challenge impeding EdTech integration." [Barrier]
Leadership support	26 (24.1%)	TE15: "Lack of understanding or support on technology by the college leaders is one of the barriers to technology integration." [Barrier] TE1: "Even though the support is not sufficient laptops, LCD projectors, desktop computers, and technology rooms are being provided." [Driver]
Institutional vision and plan	20 (18.5%)	TE9: "The current administration has a vision and plans to aggressively work on technology integration." [Driver] ARVD3: "We do not have harmonised and institutionalised guidelines to lead the integration of EdTech." [Barrier]
Leadership perception	20 (18.5%)	TE3: "the leadership in this college is only limited to installing the internet lines." [Barrier]
Leadership attitude	10 (9.3%)	TE5: "Having a positive attitude toward this issue is very important. Sometimes, teachers blame the leaders in this regard." [Barrier]

Participants reported mixed leadership commitment to EdTech: Some leaders lacked dedication to acquiring technologies (TE3, TE5 and TE11), while others supported initiatives (TE7, TE9). Leaders' limited awareness of modern technologies (TE3, TE9, TE14 and TE15) resulted in insufficient ICT budgets (ICTD3) and disinterest in ICT-based systems (TE10 and ICTD2), exacerbating poor infrastructure and teacher readiness (TE5 and TE14). Although leadership support is pivotal (TE7), administrative hurdles (ICTD1) and the absence of external support (ICTD2) hindered integration. EdTech integration is prioritised in the colleges' strategic plan; however, translating this vision into practice continues to face significant hurdles. The findings underscore institutional readiness as a key factor in enabling or impeding EdTech integration.

Student digital competence

Table 4 shows the core category representing students' technology knowledge, skills and experience with technologies. The impact of student technology knowledge on teachers' technology integration was underscored by many participants. For instance, TE1, TE13, TE14 and TE15 were among those who claimed its impact on their effectiveness in EdTech integration.

Table 4
Subcategories of students' digital competence

Subcategory	Frequency of coded segments	Sample verbatim extracts
Student digital skills	10 (18.9%)	TE12: "Students do not have the technological skills to access the internet and other platforms, including their smartphones." [Barrier]
Student technology knowledge	32 (60.4%)	TE6: "Our students are not literate even though we are in the 21st century, even though students have smartphones and different technologies." [Barrier]
Student experience	11 (20.7%)	TE1: "Our students lack appropriate experience in using EdTech." [Barrier]

Students' digital skills indicate their ability to use digital tools for learning. As perceived by most TEs, students lack digital skills, which affects their technology use for classroom instruction. For example, TE2, TE3 and TE12 acknowledged the technological skill gap of students in using their smartphones for educational purposes. As evident from the interview excerpt of TE1, limited student knowledge, experience and practice make technology-enhanced lessons challenging. Generally, problems related to the student's technology knowledge, exposure and experience were cited as barriers to TEs' EdTech integration.

TE attitude

As presented in Table 5, this core category encompasses the TE's attitude and perception toward using EdTech. Perception is a foundation for an attitude that promotes TEs' engagement with digital technologies. The category is named after attitude for its frequent claim by multiple participants rather than perception, which is mentioned only by higher officials.

Table 5
Subcategories of teacher educator attitude

Subcategory	Frequency of coded segments	Sample verbatim extracts
Attitude	36 (87.8%)	TE14: "From the teacher's perspective, the first is being change-resistant." [Barrier]
Perception	5 (12.2%)	ICTD1: "most instructors perceive educational technology as the use of a projector." [Barrier]

Attitude reflects TEs' evaluations, emotions and predispositions toward EdTech. Key dimensions include resistance to change, beliefs, and openness. Most participants (e.g., TE6, TE7, TE12, TE14 and TE15) reported TEs' resistance to technology use, with many lacking openness or positive attitudes (e.g., TE7, TE12, TE14 and TE15). Higher officials (e.g., ARVD2 and ARVD3) corroborated these observations, noting TEs' scepticism towards modern tools.

Perception, distinct from attitude, captures TEs' interpretation of technology's role in education. Administrators (e.g., ARVD1 and ICTD1) highlighted TEs' negative perceptions, such as viewing technology as irrelevant or disruptive. Collectively, the findings underscore how TEs' attitudes hinder effective EdTech integration.

Professional development

This core category underscores the availability or lack of training or professional development opportunities for TEs to alleviate their limitations in EdTech integration. Table 6 contains its subcategories. Principally, lack of training, which could be short or long term, was found to be significantly influencing EdTech integration. Additionally, several TEs highlighted it as a challenge for integrating technologies (e.g., TE2, TE4, TE6, TE7, TE8 and TE10). Continuous professional development supports TEs' ongoing EdTech integration. For instance, TE14 noted that updating skills enhances preparedness and effectiveness in EdTech integration.

Table 6
Subcategories of training and professional development

Subcategory	Frequency of coded segments	Sample verbatim extracts
Training	24 (77.4%)	TE6: "Lack of training is one of the challenges that we usually face in our college." [Barrier]
Continuous professional development	7 (22.6%)	TE8: "The trainings are not as such ongoing. They are interrupted." [Barrier]

Technology integration readiness

As shown in Table 7, the concepts of willingness, readiness and commitment are anchored by the central theme of technology integration readiness. It underscores TEs' preparedness and commitment to integrating EdTech.

Table 7
Subcategories of technology integration readiness

Subcategory	Frequency of coded segments	Sample verbatim extracts
Willingness	24 (40%)	TE2: "It is only my self-initiative that is driving me to use technology on a very small scale." [Driver] TE7: "Most of us are not willing to use technologies." [Barrier]
Readiness	19 (31.7%)	TE3: "when you have confidence in some technological skills, you can easily perform." [Driver] ICTD3: "TEs are not ready to adopt or utilise educational technology." [Barrier]
Commitment	17 (28.3%)	TE6: "Lack of commitment is one of the problems that we usually encounter in schools." [Barrier] TE8: "Committed instructors can accept and integrate EdTech." [Driver]

Teacher willingness, driven by intrinsic motivation and self-initiative, emerged as the most frequently mentioned factor among participants (e.g., TE2, TE3, TE7, TE9, TE10, TE11, TE14 and TE15). Higher officials also highlighted the lack of TEs' willingness as a barrier to EdTech integration (ARVD1 and ARVD3). On the other hand, readiness denotes TE's confidence and preparedness to adopt EdTech in teaching, which was also lacking. ARVD1 emphasised that TEs must be ready to practise EdTechs in teaching-learning, while ICTD3 noted that many are struggling. Finally, commitment, the sustained effort to integrate and enhance EdTech, was deemed crucial. However, TEs' inconsistent dedication hindered progress (e.g., TE6 and TE8).

Curriculum alignment

This core category represents the alignment of EdTechs with the curriculum. As shown in Table 8, it consisted of the subcategories, curriculum and course-related issues. It ensures the effective integration of EdTech and makes teaching meaningful and relevant to educational objectives.

Table 8
Subcategories of curriculum alignment

Subcategory	Frequency of coded segments	Sample verbatim extracts
Curriculum issues	17 (54.8%)	TE12: "The curriculum is based on the traditional model, which is talk-and-chalk based." [Barrier]
Course-related issues	14 (45.2%)	TE11: "The teaching materials are not prepared in a way that promotes the use of EdTech." [Barrier]

The curriculum issues were attributed to a lack of technologies in the curriculum, course and teaching materials. Most TEs indicated that the curriculum is based on a traditional model that ignores technology integration (TE2, TE3, TE9 and TE13). Course-related issues are accounted for by the nature of the course and the lack of technology in the course and teaching materials. Most of the participants claimed the effect of the nature of the course on their EdTech integration (TE4, TE7, TE8, TE10 and TE11). Additionally, few participants indicated the absence of technologies in teaching materials and in the courses (TE10, TE11 and TE15). Overall, curriculum alignment is one of the contributors to the failure of EdTech integration in CTEs.

Simplicity and usefulness of technology

As presented in Table 9, this core category reflects the TEs' tendency to use simple and useful EdTechs. Technologies that are easy to use and demonstrate clear benefits are more likely to be integrated effectively.

Table 9
Subcategories of simplicity and usefulness of technology

Subcategory	Frequency of coded segments	Sample verbatim extracts
Simplicity	17 (68%)	TE10: "If technology is so simple, I will be very interested in using such technology." [Driver] TE9: "If technologies are difficult to utilise, integrating them for teaching or learning becomes impossible." [Barrier]
Usefulness	8 (32%)	TE12: "Using technology like augmented reality can simplify demonstrating concepts virtually." [Driver]

Concerning the simplicity of technology, some participants indicated its importance for effective integration (TE7, TE8 and TE10). On the other hand, complex technologies create frustration (TE9 and TE10). Therefore, EdTechs should be simple to be successfully integrated. The usefulness of technology is related to its relevance in addressing learning goals. Accordingly, EdTechs play a substantial role in simplifying communication and addressing different types of learning styles (TE1). Additionally, it allows sharing of electronic resources and replaces traditional tools (TE7 and TE12). Ultimately, the findings depict the role of simplicity and usefulness of technology in facilitating EdTech integration.

Colleague influence

The influence of colleagues and the collaborative environment within CTEs can significantly affect the adoption and integration of EdTechs. As indicated in Table 10, this core category is constructed from two subcategories with related concepts: collaboration and peer influence.

Table 10
Subcategories of colleague influence

Subcategory	Frequency of coded segments	Sample verbatim extracts
Peer influence	21 (77.8%)	TE3: "those with a better digital competence will positively influence others to at least attempt such technologies in their teaching and learning practices." [Driver] TE10: "The influence of my colleagues is very crucial in effectively integrating EdTech." [Driver/Barrier]
Collaboration	6 (22.2%)	TE7: "Teachers who are willing and open to use technologies, they support me, and I support them." [Driver]

Peer influence is related to the positive or negative effect of colleagues while engaging in innovative teaching practices. Most participants indicated the significant role of peers in sharing skills and experiences. Conversely, some colleagues lack the willingness to integrate and support others (TE2, TE7 and TE14). Likewise, collaboration involves sharing experiences, skills and knowledge among colleagues on essential technologies. As noted by a few participants, it helps to solve immediate problems (TE8).

Theory development

This section presents the emergent theory derived from the data and existing theories, under the principles of CGT (Charmaz, 2014). In the final phase of the CGT study, we conducted a literature review to explain the constructed core categories and refine the emerged theoretical explanations. The core categories are classified into two categories (i.e., internal and external factors) (Cheng et al., 2020). The internal factors include digital competence, tech usability, attitude and readiness. The external factors include colleague influence, professional development, student digital competence, curriculum alignment, institutional readiness and resource and support. Memos and verbatim extracts are provided as evidence for the claim in each theoretical relationship. Theoretical mapping, based on the reviewed literature, was conducted to confirm theoretical saturation. Therefore, the final framework is based on empirical data and existing theories.

Theoretical explanations for the internal factors

Digital competence directly influences tech usability, readiness and EdTech Integration. Several studies claim the effect of digital competence on EdTech integration (Ferede et al., 2022b; Laudari & Prior, 2020; Schlebusch et al., 2024). Tech usability is presumed to influence attitude and readiness, which aligns with findings from Indian higher education institutions (Singh et al., 2023). Attitude directly affects readiness, which indirectly influences EdTech integration. Multiple studies around the globe have uncovered the effect of teachers' attitudes on EdTech integration (Ferede et al., 2022b; Mat Dangi et al., 2022; Mpuangnan, 2024; Nyakito et al., 2021). Finally, readiness, which is influenced by digital competence, tech usability and attitude, influences EdTech Integration (Graham et al., 2024). The following quotes from interviews and memos from the CGT analysis are provided to support the theoretical explanations:

> TE1: To judge whether the given technology is simple and useful, first we need to know such technologies. [Digital competence→Tech usability], (Source: In-document memo)

> ARVD1: Having a clear understanding of the technologies motivates teachers to employ technologies in their instruction. [Digital competence→Readiness], (Source: In-document memo)

> TE10: When the technologies are simple, I am very interested to use them. [Tech usability→Attitude], (Source: Interview)

> TE11: It is obvious that, if things are simple, everyone attempt or become ready to use technology, so simplicity matters. [Tech usability→Readiness], (Source: Interview)

> TE11: If teacher educators have a positive attitude, they may attempt to use cell phones to integrate EdTech in their classrooms. [Attitude→Readiness], (Source: Interview)

> TE6: In fact, we are living in a developing country; however, we can use technologies if we are committed. [Readiness→EdTech Integration], (Source: Interview)

> TE2: Teacher educator knowledge, skill and experience affect the integration of technology. [Digital competence→EdTech Integration], (Source: In-document memo)

Theoretical explanations for the external factors

External factors such as colleague influence, student digital competence, professional development, resource and support, curriculum alignment and institutional readiness affect the internal and external factors directly or indirectly. The following paragraphs present the relationships stemming from each factor.

Concerning colleagues' influence, two theoretical relationships were identified. The first links with digital competence and the second with readiness. Colleagues can positively or negatively influence TEs' readiness to integrate EdTech (Campbell & Frawley, 2024). Also, colleagues collaborate and share experiences to enrich their digital competence (Hoang, 2024). The following quotes support the theoretical relationships:

> TE14: Most of the skills, especially in technology, are gained from our colleagues. [Colleague influence→Digital competence], (Source: Interview)

> TE7: Teachers who are willing and open to use technologies, they support me, and I support them. [Colleague influence→Readiness], (Source: Interview)

Student digital competence affects TEs' willingness to integrate EdTech. Additionally, it influences the integration of technologies in the teaching-learning process. Empirical evidence from developing countries supports these theoretical claims (Ifinedo & Kankaanranta, 2021; Nyagorme et al., 2022). The next quotes present empirical evidence for the claimed theoretical relationships:

> TE1: Students' level of understanding, knowledge and experience are significant factors that may not initiate us to use such technologies. [Student digital competence→Readiness], (Source, Interview)

> TE13: Students familiarity with technology can help the teacher to effectively integrate EdTech into the lesson. So, the technology literacy of students has an impact on the effectiveness of EdTech integration. [Student digital competence→EdTech Integration], (Source: Interview)

Professional development affects TEs' digital competence and readiness for EdTech integration. It plays a key role in motivating their engagement in technology-enhanced educational activities. The quotes presented below support these claims. Further, these relationships are corroborated by the EdTech literature (Hinojo-Lucena et al., 2019).

> TE2: Even though I have a great desire to have this knowledge, the gap has happened due to lack of training. So, there is a great need for training that could fill the knowledge and skill gaps. [Professional development→Digital competence], (Source: Interview)

> TE13: Maybe, my intention to integrate EdTech can be affected by the lack of prior knowledge about technology, lack of training, and practice. [Professional development→Readiness], (Source: Interview)

ICT resources and support affect teacher readiness and effectiveness in EdTech integration. The findings are substantiated by empirical studies conducted in developing countries (Ifinedo & Kankaanranta, 2021; Nyakito et al., 2021; Roy et al., 2021). The following evidence from the interview and in-document memo support the claims:

> TE11: The classroom by itself is not suitable for using technology. Because the rooms are not designed in a way that support or enable the use of technologies. [Resource and support→EdTech Integration], (Source: Interview)

> TE5: If we ask the maintenance personnels to maintain a computer failed to work, they do not respond, though we insist them frequently. [Resource and support→EdTech Integration], (Source: Interview)

TE8: The availability of a conducive environment to integrate technology increases teacher's motivation. Motivated teachers are highly encouraged to integrate EdTech into their classrooms. [Resource and support→Readiness], (Source: In-document memo)

Curriculum alignment with technology affects TEs' readiness and actual integration of EdTechs. Studies conducted in developed countries (Mercader & Gairín, 2020) and developing countries (Ifinedo & Kankaanranta, 2021; Nyakito et al., 2021) revealed the impact of the curriculum on the effectiveness of EdTech integration. The next verbatim excerpts illuminate the theoretical claims:

TE5: The curriculum should be designed in a way that promote EdTech integration into the teaching-learning process. But, when we see the overall course organisation, the mechanisms for integrating EdTech into the teaching-learning process are not considered. [Curriculum alignment→EdTech Integration], (Source: Interview)

TE12: The curriculum is based on the traditional model which is talk-and-chalk based. So, teachers do not try to modify and integrate technology into their teaching practice. Because they are familiar with the traditional teaching approach. [Curriculum alignment→Readiness], (Source: Interview)

Institutional readiness is a significant factor in EdTech integration. The findings revealed that institutional readiness affects resource and support, professional development, digital competence, readiness and EdTech integration. Multiple studies confirmed its key role in promoting EdTech integration (Ntorukiri et al., 2022; Petko et al., 2018; Yuting et al., 2022). The following quotes support each claim:

TE2: To enhance the use of technology, managerial skills are very vital. Because, for example, motivating teachers, arranging training, etc., are managed by the college management. [Institutional readiness→Readiness, Institutional readiness→Professional development], (Source: Interview)

TE15: The leadership is committed to establishing numerous technological facilities like data centres, digitalising course materials, and providing various connection mechanisms for students and teachers. [Institutional readiness→Resource and support], (Source: Interview)

TE7: Leaders have big potential to motivate and push us to use EdTechs in the instructional process. [Institutional readiness→Readiness, Institutional readiness→EdTech Integration], (Source: Interview)

ARVD3: We do not have a harmonised and institutionalised guidelines to lead the integration of technology. However, some teachers utilise technologies based on their self-initiative. [Institutional readiness→EdTech Integration], (Source: Interview)

TE8: If there is a poor management in the college, this has a negative impact that affects the ability and the decision of instructors to integrate EdTech. [Institutional readiness→Digital competence], (Source: Interview)

As a result, the theoretical framework shown in Figure 2 emerged from the theoretical explanations, empirical data, and participant interactions.
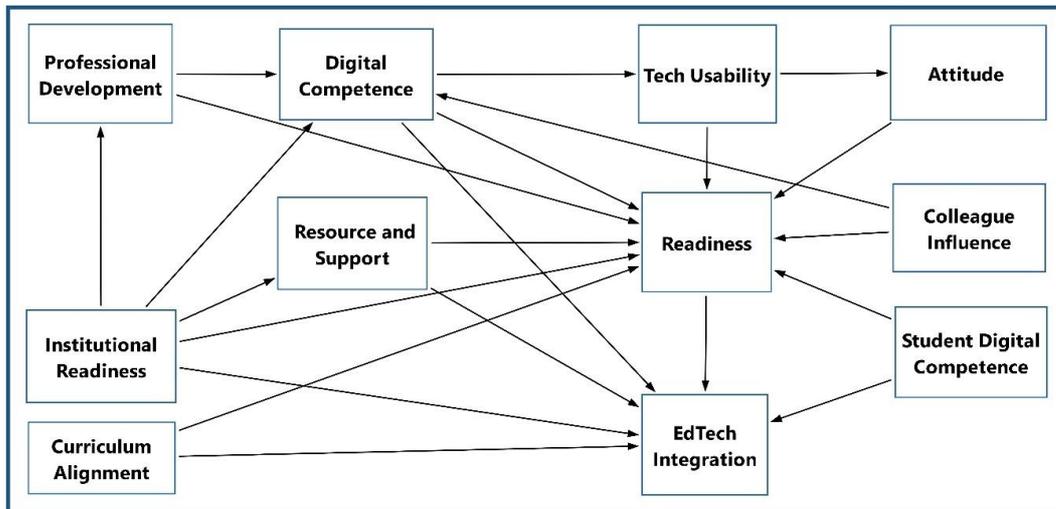
Figure 2. A theoretical framework based on empirical data

Theoretical mapping

Following the principles of CGT, existing theories were consulted to build a comprehensive theoretical framework. Activity theory (AT; Engeström, 2014), the technology acceptance model (TAM; Davis, 1989) and the unified theory of acceptance and use of technology (UTAUT; Venkatesh et al., 2003) were found appropriate to offer complementary perspectives for the developed theoretical framework.

The AT is used in EdTech research as a lens to explain research findings (Cochrane et al., 2022). It provides a systemic perspective on how different components of an educational system interact in shaping EdTech integration. The core categories identified in this study align well with AT's key elements (Engeström, 2014):

- Subjects: Teacher educators, college leaders, and ICT support staff who engage with the EdTech integration effort.
- Tools: Digital technologies and ICT infrastructure.
- Community: Institutional leadership, ICT directors, ICT support staff, policymakers, curriculum designers, colleagues, and students.
- Rules: Institutional EdTech policy, national ICT frameworks, and curriculum.
- Division of labour: EdTech users, decision-makers, technical support providers, and policymakers.
- Object: EdTech integration
- Outcome: Quality education.

Additionally, the theoretical relationships can be examined through the lens of AT. For example, institutional readiness and, resource and support demonstrate a reciprocal dynamic: institutional readiness influences the allocation and accessibility of ICT resources, while the availability of these resources, in turn, strengthens institutional commitment to EdTech integration. Sufficient ICT infrastructure not only allows TEs to seamlessly integrate EdTech but also encourages institutional investment in expanding ICT support as the demand for EdTech rises. Simultaneously, institutional readiness – reflected through policies, training and infrastructure – establishes a foundation for enhancing TEs' digital competence. On the other hand, improvements in TEs' digital competence prompt institutions to further develop their capacity for EdTech adoption. Peer collaboration and knowledge sharing among TEs also play an essential role in cultivating digital competence, which, once fortified, empowers TEs to mentor colleagues and advocate for systemic support. Moreover, although both institutional and individual readiness are essential for EdTech integration, the successful implementation of EdTech further enhances readiness by building trust, refining strategies, and creating positive feedback loops. These

interdependencies highlight the bidirectional and mutually reinforcing nature of the factors influencing EdTech integration within the AT framework.

TAM is the most common model used to investigate the acceptance and use of EdTech in higher education (Singh et al., 2023). Based on this model, perceived ease of use and usefulness are the two significant predictors of technology adoption. Table 11 summarises the mapping of the constructs with TAM.

Table 11
Mapping of constructed GT constructs with TAM (Davis, 1989)

Constructed GT constructs	TAM constructs
EdTech integration	Actual use
Readiness	Behavioural intention
Attitude	Attitude
Tech usability	Perceived ease of use
	Perceived usefulness
Digital competence	External variable

As shown in Table 11, all the constructs are mapped one to one, except for tech usability. Tech usability corresponds to perceived ease of use and perceived usefulness. However, the remaining constructs align perfectly with those under TAM. Additionally, digital competence extends TAM as an external variable. To ensure that the constructed GT aligns with existing theoretical concepts, the unmatched constructs must be replaced with those in TAM. Consequently, digital competence influences perceived ease of use and perceived usefulness separately. Furthermore, these two constructs affect attitude independently.

Moreover, some of the remaining constructs of the CGT can be explained using UTAUT, which is a popular model in studies concerning EdTech integration in higher education (Nikolic et al., 2024). According to this theory, performance expectancy, effort expectancy, social influence and facilitating conditions are the four determinants of users' behavioural intention to use technology (Venkatesh et al., 2003). Table 12 summarises the mapping of constructs between the constructed GT and UTAUT.

Table 12
Mapping of constructed GT constructs with UTAUT (Venkatesh et al., 2003)

Constructed GT Constructs	UTAUT constructs
Tech usability	Performance expectancy
	Effort expectancy
Colleague influence	Social influence
Resource and support	Facilitating conditions
Readiness	Behavioural intention

As indicated in Table 12, all constructs are mapped one to one, except for performance and effort expectancy, similar to TAM. These two constructs are related to the construct tech usability. Among the mapped constructs of UTAUT, tech usability and readiness are also mapped with TAM constructs. Additionally, colleague influence, and resource and support can be explained in terms of social influence and facilitating conditions, respectively. Therefore, our constructed GT aligns with UTAUT. The remaining constructs – curriculum alignment, institutional readiness, professional development and student digital competence – in the constructed GT extend both UTAUT and TAM. Furthermore, the theory is robust and grounded in empirical data and established theories. Figure 3 presents the final version of the theoretical framework.
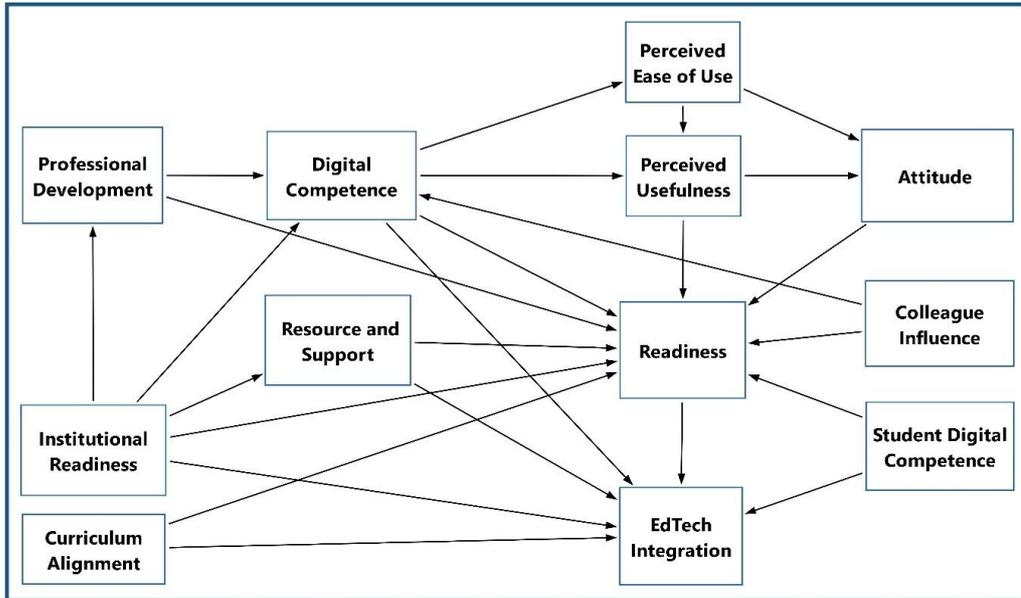
Figure 3. The theoretical framework of factors influencing EdTech integration in CTEs

Validation of findings

A member-checking survey was conducted to confirm the credibility of the findings and the theoretical explanations. Among the 12 respondents (see Figure 4), the highest agreement was observed for digital competence (100%), followed by resource and support (91.7%) and curriculum alignment (91.7%). Institutional readiness, student digital competence, professional development, readiness, perceived ease of use and colleague influence each received strong agreement (83.3%), though one participant disagreed with colleague influence. Attitude (58.3%) and perceived usefulness (66.7%) showed relatively lower agreement, indicating some divergence in participant perspectives. Overall, the findings demonstrate high validity, reinforcing the relevance of the identified factors in EdTech integration.
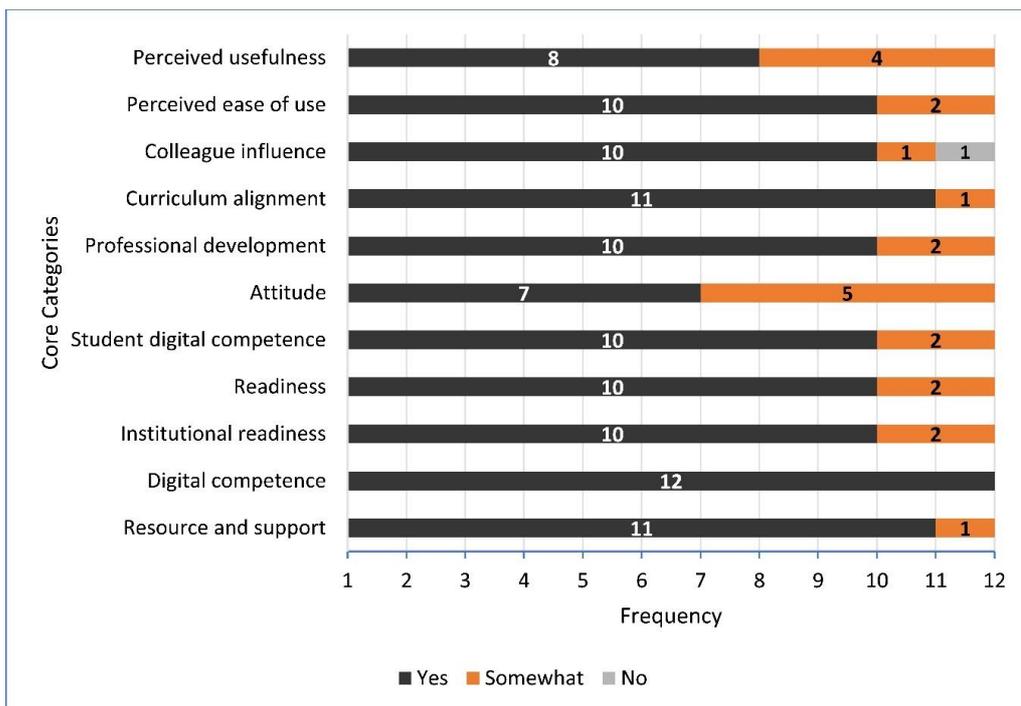
Figure 4. Summary of member-checking survey

Discussion

This study explored TEs' insights into and experiences with the contextual factors affecting their EdTech integration and constructed a theoretical framework. The identified factors were categorised into two: internal and external. External factors consisted of institutional readiness, curriculum alignment, student digital competence, colleague influence, professional development and resource and support. Internal factors consisted of digital competence, attitude, readiness, ease of use and usefulness of technology. The framework, grounded in empirical data, was enriched by existing theories. This section compares the findings with the literature to ensure the theory's relevance and contribution to the existing body of knowledge.

In this study, the factors identified as external are often faced by most developing countries. In nations such as Nigeria, Bangladesh and Uganda, TEs struggle with insufficient ICT infrastructure, lack of professional development and weak institutional support (Ifinedo & Kankaanranta, 2021; Nyakito et al., 2021; Roy et al., 2021). The current study also highlighted institutional readiness and leadership support as major determinants of EdTech integration. The findings align with global research showing that leadership commitment, vision and policy enforcement are crucial in determining the success of EdTech initiatives (Toader et al., 2023). Further, the factors, including lack of technology in the curriculum, student digital competence and colleagues' influence, are also reported in developing countries, such as Nigeria, Uganda and Ghana (Ifinedo & Kankaanranta, 2021; Nyagorme et al., 2022; Nyakito et al., 2021).

The TEs' lack of digital competence emerged as a significant factor in the current study, a finding echoed in most developing countries. Research findings from Nepal (Laudari & Prior, 2020) and South Africa (Schlebusch et al., 2024) showed that teachers have been found to lack competencies in EdTech integration. Likewise, teachers' readiness, attitude, perceived ease of use and usefulness are also reported as key factors for EdTech integration from higher education institutions of emerging economies (Al-Adwan et al., 2024; Mat Dangi et al., 2022; Nyakito et al., 2021). The findings underscore the need for a systemic intervention that addresses internal and external factors to ensure effective EdTech integration.

This study contributes a novel, empirically grounded theoretical framework integrating CGT findings with AT (Engeström, 2014), TAM (Davis, 1989) and UTAUT (Venkatesh et al., 2003). Although TAM and UTAUT explain individual adoption factors, AT provides a systemic lens to interpret institutional and leadership influences. This comprehensive model advances EdTech integration research by bridging individual, institutional, and systemic dimensions in teacher education. Further, this study starts to fill the gap in the literature on EdTech integration frameworks in developing countries.

The study highlights the critical role of TEs' digital competence in EdTech integration. To fill this gap, CTEs in developing countries should implement continuing professional development programmes promoting EdTech integration into pedagogy, encourage peer mentorship programs and align training programmes with UNESCO's (2018) ICT competency framework to ensure structured and progressive skill development. College leadership should establish a clear institutional vision for EdTech integration, provide incentives and recognition programs to encourage TEs' EdTech integration, collaborate with government and non-governmental organisations to secure resources, establish dedicated ICT support staff and develop accountability measures to ensure leadership support translates into actionable strategies. The regional education bureau should develop and enforce institutional EdTech integration policies to enhance EdTech integration in CTEs. Ministries of education should support CTEs through digital resources and expertise to capacitate their ability to facilitate effective EdTech integration. TEs should engage in workshops, seminars and online courses to stay updated on EdTech tools, collaborate with peers to share best practices and foster an innovative mindset for adopting new technologies. Furthermore, given the similarities of the challenges influencing EdTech integration across developing nations (Ezumah, 2020), the findings can serve as a benchmark.

Despite the study's contributions, certain limitations should be acknowledged. First, as a CGT study, data collection and analysis were conducted iteratively until theoretical saturation. However, theoretical saturation is inherently subjective and context-dependent; that is, some aspects of EdTech integration may require further exploration in different institutional settings or countries. Second, the study was conducted in selected CTEs, and although the findings are transferrable to similar institutions, they do not claim statistical generalisability. Third, the data collection solely relied on interviews, observation and document analysis, which, despite their depth, could be complemented by quantitative validation. Finally, although TEs and institutional leaders were key informants, the perspectives of students and policymakers were not included.

The current study has implications for future studies. First, a follow-up quantitative study would provide a more comprehensive understanding of factors influencing EdTech integration in Ethiopian CTEs. Second, a related study could be conducted, adding more CTEs. Third, comparative research on EdTech integration in developing countries with similar education systems would help to generalise across settings. Fourth, the applicability of the developed framework can be tested in other countries. Fifth, different stakeholders could be considered when constructing a comprehensive EdTech integration framework. Finally, experimental studies investigating the effectiveness of specific interventions, such as targeted digital training programs or policy reforms, would provide evidence-based recommendations for improving EdTech integration in CTEs.

Conclusion

In this study, we explored the contextual factors influencing EdTech integration and developed an EdTech integration theoretical framework consisting of 11 core categories. We revealed the multifaceted nature of the factors based on the principles of CGT. These factors are broadly categorised into two: internal and external. The findings show that ICT resource and support, digital competence and institutional readiness are the most determinant factors. Shortage of ICT resources and poor infrastructure are predominantly affecting teachers' ability to integrate EdTech. In line with this, access to technologies and technical support are challenges that need institutional intervention. In addition to the mentioned factors, teacher's readiness, attitude, students' digital competence, professional development, curriculum, colleague influence, ease of use and usefulness also affect EdTech integration. Technology integration readiness is a critical factor influenced by all factors in the constructed framework that influence EdTech integration. The findings could support concerned stakeholders in addressing the pitfalls of EdTech integration in developing countries. Above all, a member-checking survey confirmed the credibility of the findings, revealing that all factors are significant predictors of EdTech integration. In conclusion, this study highlights the factors influencing EdTech integration in CTEs in developing countries, particularly Ethiopia, to achieve Sustainable Development Goal 4 (United Nations, 2015).

Author contributions

Misganaw Tadesse Woldemariam: Conceptualisation of study, Interview guide development, Member-checking survey development, Data collection and analysis, Writing – original draft, Writing – review and editing; **Worku Jimma**: Conceptualisation of the study, Supervision, Validation, Review and editing; and **Amanuel Ayde Ergado**: Supervision, Validation, Review and Editing. All authors reviewed and approved the final version of the manuscript.

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