Determinants of digital inclusion in higher education: Exploring the Ethiopian context

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Table of Contents

List of Tables

List of Figures

List of Abbreviations

AAU: Addis Ababa University

AMU: Arba Minch University

BDU: Bahir Dar University

CPD: Continuous Professional Development

CRPD: Convention for the Rights of Persons with Disabilities

DAISY: Digital Accessible Information System

ESDP: Education Sector Development Plan

HEI: Higher Education Institution

HU: Hawassa University

ICT: Information and Communication Technology

IMS: Instructional Management Systems

ITU: International Telecommunication Union

JU: Jimma University

LMS: Learning Management System

SDG: Sustainable Development Goals

UDL: Universal Design for Learning

WCAG: Web Content Accessibility Guidelines

W3C: World Wide Web Consortium

1. Executive Summary

The research aimed to explore the state of digital inclusion in Ethiopian higher education and recommend policy recommendations. Review of the available literature shows that there is a recognition of the role that information and communication technologies (ICT) play to improve education. Nevertheless, there are gaps that this research aimed to fill. The first is the lack of a clear definition of digital inclusion. The second is the need for comprehensive guidelines or strategies to ensure digital inclusion in education.

The research adopted a bottom-up approach to identify the existing digital divide in higher educational institutions and recommend ideas that could help to remove the barriers. Five of the biggest universities in the country namely Addis Ababa University, Hawassa University, Bahir Dar University, Arba Minch University, and Jimma University were selected for the research. Out of the total 76,206 undergraduate students studying at the five universities, questionnaires were completed by 418 of them. Moreover, in-depth interviews were made with 15 academicians in the universities. The questions revolved around issues, such as access to ICT, access to educational materials, digital literacy, and barriers of access to ICT and educational materials.

43% of the respondents (who are students) said that they own PCs and 90% of them also said they own smartphones. 7% said they have tablets. Those who don't own computers made use of shared access facilities, such as library computer sections (22%), and computer labs (22%); and also shared their friends' computers (10%). In addition to financial constraints that prevented access to computers and the Internet, problems encountered with shared access facilities, such as insufficient number of computers in computer rooms, weak Wi-Fi connections, and poor Internet connection were among the problems discussed. Further analysis of barriers in relation to the respondents' background (i.e., rural, semi-urban, and urban), users' ICT devices, and past history of ICT education was made in the research. The other major issue identified is related to digital content. Learning Management Systems (LMSs) are under-utilized though there have been improvements during the COVID-19 shutdown. Moreover, there are inconsistencies in the use of LMSs with some teachers using the tools, while others preferred to use the social media app, Telegram and e-mail to communicate with their students. This shows the lack of policies and guidelines that govern the use of educational resources. Another problem in relation to content is accessibility. Efforts to address the needs of students with disabilities were limited to production of content in Braille form and provision of audio recording tools to students with visual impairments. There is a lack of knowledge of accessibility and accessibility guidelines. Another major issue is related to usage and motivation to use ICT for educational purposes. That was attributed to the structural issues in the universities and the varying digital literacy levels of both teachers and students.

The solutions this research recommended to remedy the situations included the development of a digital inclusion policy that recognizes the technical, socio-demographic and socio-economic barriers that are explored in the study. That would help to create a shared understanding of digital inclusion and institute consistent practices that maximize the use of the available educational resources. Thereafter, implementing digital literacy programs (including computer literacy, ICT literacy,

information literacy, and media literacy) that target different groups are important. Establishment of inclusive ICT infrastructures that incorporates the needs of persons with disabilities, working with different governmental and non-governmental partners to ensure on-campus and off campus access to ICT resources are among the recommendations discussed in this paper.

2. Introduction

Information and communication technologies (ICTs) have brought the opportunity so that, regardless of distance and time barriers, everyone with connectivity can enjoy the opportunities technology has made possible. As witnessed through the COVID-19 pandemic, technology offers tools for people to remain resilient in their day-to-day activities while keeping themselves safe. Nevertheless, there are barriers.

The "digital divide", which is mainly understood as the gap between those who have access to ICTs and those who don't, is predominant especially in developing countries like Ethiopia. Times such as the COVID-19 pandemic cause such countries to be more vulnerable as their citizens may lack the alternative path to resume their businesses from the safety of their homes. Nevertheless, digital divide is not a simple dichotomy of haves and have nots as there are variety of socio-demographic, socio-economic, and personal factors that may affect people's use of ICTs (Lythreatis et al., 2022). Thus, past studies looked at the phenomenon from different perspectives and different levels of depth. For instance, Nielsen (2006) discussed "stages of digital divide" as economic divide, usability divide, and empowerment divide. The economic divide is described in terms of whether someone affords computer or connectivity to the Internet. The usability divide relates to digital literacy, i.e., the ability to use ICT, and the accessibility of a digital service for seniors, persons with disabilities and others with digital literacy but face difficulties to use digital services. The empowerment divide relates to the ability of individuals to search, find, and use information and contribute information to platforms, such as social networks and community systems. Others adopt typology to identify the first, second, and third digital divides. The first digital divide is explained in terms of having or not having access to ICTs and the skills to use them (Alam & Imran, 2015; Barnard & Merwe, 2015). The second digital divide relates to digital services design and their accessibility to different groups such as persons with disabilities (Trucano, 2010). The third digital divide refers to whether individuals have achieved tangible benefits out of their use of ICT (Ogbo et al., 2021; Ragnedda, 2017; van Deursen & Helsper, 2015). Digital inclusion is a concept that describes efforts to bridge the digital divide in whichever manifestation it may appear and ensure digital equity (Hamburg & Lütgen, 2019)

Education is one of the activities which was highly affected by the COVID-19 pandemic as schools were forced to close. The pandemic provided an opportunity first to appreciate the potential of ICT to withstand disruption and provide an alternative venue for the teaching-learning process to resume. Second, it revealed the existing digital divides in education that need addressing. This research adopted a broader view of the digital divide to identify technical, organizational, socio-demographic, socio-economic, and personal factors that determine digital inclusion in Ethiopian higher education system. This understanding is used as a framework to design the data collection tools and analyze the findings.

This research was conducted as part of the International Telecommunication Union (ITU)'s "Connect2Recover Research competition"[1]. The Connect2Recover initiative aims "to build back better with broadband by reinforcing digital infrastructure and digital ecosystems of countries so that they can better leverage ICTs to support COVID-19

[1] https://www.itu.int/en/ITU-D/Pages/connect2recover/research-competition/winners/default.aspx

pandemic recovery efforts and preparedness for a post-COVID normal and remain resilient in times of disasters"[2]. One of the objectives of the research competition was to "Improve research focus on digital resiliency and digital inclusion to build back better with broadband for pandemic recovery". The proposal of this research was one of the 15 that won the competition. Three virtual information sessions were organized for the research competition papers to share the planned and ongoing works[3]. This research was presented in one of the information sessions prepared for the papers focusing on Africa.

This paper is organized as follows: Chapter 2 introduces the research background, research scope and research objectives respectively. Chapter 3 presents the review of literature followed by Chapter 4 which discusses the methodology used in the research. Chapter 5 presents the results and Chapter 6 discusses the results to pinpoint areas that need to be addressed in digital inclusion endeavors. Chapter 7 closes the paper with some conclusive remarks.

2.1. Background

The United Nation (UN)'s fourth Sustainable Development Goal (SDG) aims to "Ensure inclusive and equitable quality education for all and promote lifelong learning opportunities for all."[4] ICTs boost the fulfilment of this goal by providing an alternative route to education, helping the education sector remain resilient in the event of disruptions such as the COVID-19 pandemic.

The 2020 estimate by the ITU[5] shows that only 24% of Ethiopia's 115 million people are Internet users. Figures from the state-owned Ethio Telecom, the sole telecommunication operation in the country, show an increasing trend with 2.8 million (+13%) new users between 2020 and 2021. The 2020 ITU estimate shows that 85% of the population is covered by at least a 3G mobile network and 7% is covered by at least a 4G mobile network. The latest available estimate of households with mobile telephone is 68%[6]. Ethio Telecom stated that it would address digital inclusion[7], without clearly defining what digital inclusion entails. Nevertheless, remarks from high-ranking government officials seem to indicate that digital inclusion is understood as expanding connectivity to all segments of the society including girls, children, the youth and the elderly[8].

Ethiopia's Education Sector Development Program that ran its fifth phase (ESDP V) from 2016 to 2020 included a plan for integrating ICT in education, including the establishment of SchoolNET (Ethiopia-Ministry of Education, 2015). 'SchoolNET' is a cloud computing infrastructure where high school students and teachers in the country can share digital content that is centrally stored. There is also a network called

[2] https://www.itu.int/en/ITU-D/Pages/connect2recover/research-competition/default.aspx
[3] https://www.itu.int/en/ITU-D/Pages/events/connect2recover/infosessions-research-competition-papers-focusing-on-Africa/default.aspx
[4] https://www.un.org/sustainabledevelopment/wp-content/uploads/2017/02/4_Why-It-Matters-2020.pdf
[5] https://www.itu.int/en/ITU-D/Statistics/Dashboards/Pages/Digital-Development.aspx
[6] https://www.itu.int/itu-d/reports/statistics/connectivity-in-the-least-developed-countries-status-report-2021/#:~:text=The%20newly%20launched%20Connectivity%20in,States%20(UN%2DOHRLLS)%2C
[7] https://www.ethiotelecom.et/□□□□-□□□□-□□□□-□□□□-2014-2016-□□□□/
[8] https://mint.gov.et/president-sahle-work-zewde-calls-on-diligent-efforts-of-countries-to-make-digital-technology-inclusive-and-accessible/?lang=en

Ethiopian Education and Research Network (EthERNet)[9] designed to connect tertiary educational institutions (Tamrat, 2020). The ESDP V plans to implement "inclusive computer laboratories" in schools to accommodate learners with visual impairment. Other documentations show the country's vision for a greater role of ICT in facilitating teaching and making research universities paper-free in the long term (Ministry of Education, 2018). Nevertheless, past studies that investigated the existing ICT infrastructure identified problems, such as insufficient number of computers, insufficient bandwidth, lack of adequate ICT skills by teachers and students, lack of adequate content, difficulty of integrating ICT use in pedagogy, lack of policy for using ICT in pedagogical practices, and frequent system failures (Bati and Workneh, 2020; Jang, 2020; Woreta et al., 2013). Moreover, inaccessibility of computer rooms and digital libraries for persons with visual impairment were among problems discovered (Beyene et al, 2020).

The literature and documents reviewed show two main problems in the Ethiopian context. The first is the lack of a clear definition for digital inclusion. As mentioned above, the understanding seems geared towards development and expansion of ICT infrastructures. Nevertheless, viewing digital inclusion simply as expanding access to ICT would risk the omission of the individual and socio-demographic factors that affect the use of ICT. The very notion of "inclusion" implies diversity. Thus, a one-size-fits-all solution won't ensure inclusion in a meaningful way. The other problem is the apparent lack of a comprehensive strategy or guideline to ensure digital inclusion in education. This research attempted to fill those gaps.

2.2. Research Scope

The research was conducted on five selected first generation (and oldest) universities in Ethiopia. The focus was limited to examining the application of ICT in Education, including digital resources set to support the teaching-learning process.

2.3. Research Objective

This study adopted a bottom-up approach to identify existing digital divides in higher educational institutions (HEIs), and based on the findings, recommend solutions that could be considered in the Ethiopian context. To that end, this research sought answers for following questions:

- What are the digital resources available and how are they being used to support the teaching-learning process?
- How was the university's ICT capability used to support education during the COVID-19 pandemic?
- How is the current setup of the digital ecosystem in relation to digital inclusion?
- What are barriers to connectivity and access to digital resources?

3. Literature Review

Advances in technology-based learning help to ensure a robust and adaptive education system that withstands disruptions. Nevertheless, "Digital technology does

[9] https://ethernet.edu.et/

not exist in a vacuum – it has enormous potential for positive change but can also reinforce and magnify existing fault lines and worsen economic and other inequalities" (United Nations, 2020, p.2)). Several studies targeted those "fault lines" exploring problems, presenting best practices, and recommending solutions.

Problems relating to access and ICT skills are mostly related to lesser developed countries, where the infrastructures are underdeveloped and individuals cannot afford computers and connectivity due to their weak economic backgrounds (Li, 2021). Nevertheless, studies show that such problems exist in the advanced economies, too. For instance, the study by Ulzheimer et al. (2021) done on students at a German university found "insufficient technical equipment and a "deficit of digital skills". In their study made in a city in England, Clayton and Macdonald (2013) discussed the relationship between social exclusion and digital exclusion showing that people's socio-cultural-economic positions, habitus, the available opportunities, immediate requirements, and embedded practices of everyday life affect people's relationship with technology.

Schools could be places to narrow access and skills gaps. For instance, Barnard & Merwe (2015) discussed how the University of Johannesburg used South Africa's "National Student Financial Aid Scheme" to supply "underprivileged" students with tablets. The study also discussed other measures the university took, such as expanding the bandwidth connectivity of the university, installing Wi-Fi hotspots at different areas in the campus, installing electrical power points at the hotspots to enable students to charge their devices, and negotiating with telecom services to offer students unlimited off-campus Internet access. Beside developing technological capability and offering students different alternatives to learn, digital competency was another aspect of digital inclusion. It is however influenced by "occupational status and the opportunities to develop and accrue legitimate cultural capital" (Clayton & Macdonald, 2013, P.951).

Beside access and skills, content accessibility is an important element of digital inclusion. Guidelines such as Web Content Accessibility Guidelines (WCAG) provides guidance on designing accessible content. Nevertheless, the adoption of such guidelines to design educational resources seem to be at the infancy stage (Zhang et al., 2020). Universities' websites are often gateways to LMSs, digital libraries, and other digital resources. Thus, accessibility of websites is the first step to ensure accessibility of resources found behind them (Beyene, 2016; Yoon et al., 2016). Poor colour contrast, lack of alternative text for images and links, lack of labels describing the links, and lack of captions are among the typical accessibility problems identified during website accessibility tests (Ismail & Kuppusamy, 2022).

Usage is an important concept to identify whether a person, who has access and the skills to use ICT, is digitally included. According to Sanders (2020), how much and how often one uses the Internet gives a clue whether the person is digitally included or not. As discussed above, content accessibility is a factor that affects usage. Nevertheless, it would be important to recognize socio-economic and socio-demographic factors. For instance, the study by Frei-Landau & Avidov-Unga (2022) conducted on online learning experience of Bedouin and Jewish female pre-service teachers in Israel showed how different types of digital divides could affect people in different sociocultural contexts. The study presented the lack of computer and

infrastructure; potential conflict between family roles (e.g., marriage, childcare, etc.); and demands of online learning as problems reflected by the Bedouin group; whereas adjustment to online learning features and developing online learning skills were the problems discussed by the Jewish group. The study by Hummel et al, (2016) conducted in Malawi and Ethiopia claimed that gendering in daily life, for instance, domestic responsibilities, time, sociocultural norms, limitation of mobility affects women's use of ICT.

COVID-19 presented an opportunity to learn from experiences of different countries on how to use ICT to build inclusive education that may withstand disruptions. Liu (2021) discussed China's experience and presented lessons from China's "Disrupted Classes, Undisrupted Learning" initiative. First, there was a coordinated local-national policy response to mitigate learning disruption. Second, flexible learning alternatives including synchronous (real-time) and asynchronous (offline) learning options were made available through radio, television, and Internet. Third, public-private partnership was formed to leverage private sector's expertise and technological capability to offer students with better online learning experience. Liu (2021) also added that local authorities were working with telecom companies to waiver Internet fees for students of poor economic backgrounds. UNESCO IIEP (2021) discussed the Accessible Reading Materials (ARM) initiative in Bangladesh and claimed that it contributed to narrowing the digital divide during the pandemic by producing content in Digital Accessible Information System (DAISY) formats. DAISY files are also described as "digital talking books" or audiobooks where users can perform searches, navigate, bookmark, and control the reading speed[10]

To sum up, digital inclusion requires connectivity, digital abilities, affordability, and accessibility (ITU, 2021). It also requires addressing socio-demographic factors, and issues of usage that would affect equitable use of technology in education. Thus, digital inclusion concerns in education include access to digital technology, digital skills, accessibility of university websites, LMSs, and digital libraries, availability of educational resources in alternative formats, and usage of the available digital services. Moreover, adopting a shared understanding of digital inclusion by national and local authorities and formulating strategies to identify and eliminate digital barriers are important steps discussed in literature.

4. Methodology

4.1. Sample and Data Description.

Five first generation (oldest) universities, such as Hawassa University, Addis Ababa University, Arba Minch University, Jimma University, and Bahir Dar university were selected presumably for their relatively better experience of using ICT. The exploratory sequential mixed method was used in the research because it allows the research to begin with a qualitative study providing flexibility for an in-depth exploration of the research theme and follow that up with survey data (Creswell, 2013). Thus, the research started with in-depth interviews with teachers to understand the universities' state-of-the-art ICT adoption and the obstacles involved. Those responses were used to design questionnaires which were to be distributed to students.

[10] https://daisy.org/activities/standards/daisy/

4.1. 1. Interviews

Semi-structured Interviews were made with fifteen staff members including teachers, college deans, and ICT directors chosen purposefully from the five universities. The interview checklist included questions about the respondents' background, ICT access, ICT literacy, ICT experience in education, motivations to use ICT, teachers' impression of students' ICT usage, and their opinion on barriers of ICT use in education in the Ethiopian context. Some of the interview questions were inspired by UNESCO's Teachers ICT Competency Framework (UNESCO, 2017). The interviews were transcribed, and a thematic analysis was done on the interview data. A total of fifteen university teachers/administrators were interviewed. Participants from ICT, education, special needs and inclusive education, medicine, sports science, engineering, and psychology backgrounds were included in the interviews.

4.1. 2. Survey

Out of the total 76,206 undergraduate student population in the five universities, n=398 sample representatives were chosen based on stratified proportionate sampling techniques using Yamane (1967:886) formula. The sample size grew later to 418 to improve data accuracy and generalizability of the study. The survey focused on the undergraduates because they offer better diversity in background that would offer more information on different types of digital divides in the broad spectrum of digital inclusion (Table 1. shows the number of participants by university and department). Data collectors and data collection coordinators were employed at the target universities to facilitate data collection from students. The data was collected between April 1 of 2022 and May 7 of 2022.

Paper-based questionnaires were preferred for several reasons. Firstly, the students may have no or limited connectivity to the Internet. Secondly, students with disability may have difficulty if they are asked to fill in an online questionnaire. Thirdly, the respondents may be reluctant to fill an online questionnaire and that would lower the response rate. The questionnaire included demographic questions including student's gender, age, residential background (the region he/she came from, whether he/she came from rural, semi urban, or urban area), respondent's ownership of ICT devices, connectivity to the Internet, ICT skills, ICT use, barriers of access to ICT services, preferred method for accessing educational resources, opinion on ICT application in education, and participation in e-learning activities which were attempted during the COVID-19 pandemic.

74% (n=309) of respondents were male and 26% (n=111) were female. 87% (n=366) of respondents were in the age range of 20-25. 6.5% (n=27) of respondents were within the age range of 25-30. 2.4% (n=10) respondents were above the age of 30 and 3.3% (n=14) were below the age of 20.

Among the 418 participants, 6% (n=26) were students with disabilities. 12 of them were with visual impairments, 3 are with hearing impairment and one said he has both physical and cognitive impairments. 11 participants said they have disabilities but didn't specify them. Those with visual impairment had personal assistants to fill in the questionnaires.

The survey included students from different years to increase the likelihood of obtaining information from different groups. 21% (n=87) were second year students, 36.7% (n=153) were third year students, and 42.5% (n=178) were fourth year and above students.

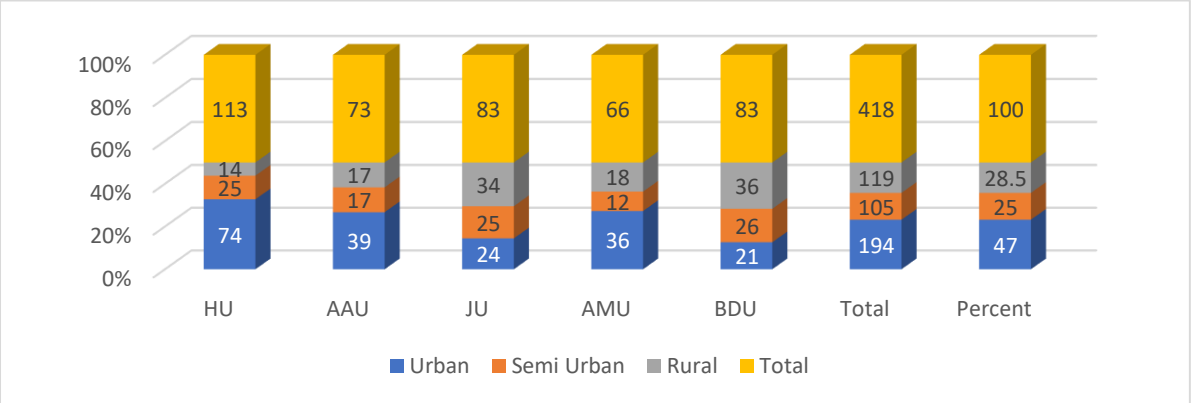
Table 1. Respondents by department

Name of Departments	Percent	University Name					Total
		Hawassa University (HU)	Addis Ababa University (AAU)	Jimma University (JU)	Arba Minch University (AMU)	Bahir Dar University (BDU)	
Special needs and Inclusive education	16.5	13	11	20	12	14	70
Educational planning & management	5.7	0	8	14	0	2	24
Mathematics	6.5	7	0	10	0	10	27
Comp science	2.2	0	9	0	0	0	9
Construction Technology Management	4.5	5	2	0	12	0	19
Geography	8.1	12	9	0	0	13	34
Psychology	2.2	0	0	0	9	0	9
Health Science	15.3	1	20	10	22	11	64
Chemistry	2.4	0	3	0	0	7	10
Physics	2.4	0	7	0	0	3	10
Physical Education	0.7	0	3	0	0	0	3
Adult Education	5.3	8	0	1	0	13	22
Civil Engineering	28	66	1	28	12	10	117
Total	100	112	73	83	67	83	418

Source: Survey data collected by the research team between April 1 of 2022 and May 7 of 2022.

The respondents were asked to specify where they were living before joining the university. 46% came from urban areas, 25% said they came from semi-urban areas, and 28% came from rural areas (see Figure. 1)

Figure 1. Respondents' residential background before joining university



Source: survey data collected by the research team between April 1 of 2022 and May 7 of 2022.

4.2. Data Analysis

The interview data was analyzed thematically, categorizing the themes by the research question they answered. Themes from the interviews were used to design the questionnaire. The questionnaire data was analyzed using SPSS. The data was used to elaborate the findings of the interviews.

4.3. Ethical Considerations

Data is collected with informed consent of participants. Questionnaires have included information on the purpose of the study and how the data would be handled. Care was taken not to include personal information. The data collected through the interviews and the questionnaires were totally anonymized to remove any information that could potentially identify a participant.

5. Results

5.1. ICT Infrastructure and Services

The first question during the interviews with university teachers and administrators (hereafter referred to as “interviewees” or “participants”) aimed to obtain the overall picture of ICT application in their universities. The discussions showed that the universities have ICT infrastructure with wired and wireless networks which include shared access facilities, such as computer rooms/labs, Internet, Wi-Fi hotspots, and computer sections in libraries. There are digital libraries which are not well developed and not accessible outside of the university compounds. There are digital repositories to store theses and dissertations, research portals where the universities upload research works, and LMSs. Participants from three of the five universities said they have computer rooms reserved for persons with disabilities.

Content is the biggest problem the universities have. The first reason is lack of resources to finance access of electronic journals and eBooks. Participants from Addis Ababa University said that their university is better when compared with the others. They said requests often come from other universities to share these resources, but there is no off-campus access to the resources. The other problem is the little or non-use of LMSs as teachers are not actively uploading content. A participant said:

> “Do teachers engage their students frequently through the university’s LMS? I don’t think so. A training has been given. However, if you take my department as an example, you don’t see teachers using the LMS. You know what? When you sit at and work on the LMS, it is with the belief that students would use it. However, when you know that most of the students don’t have access to technology, then you wouldn't have the motivation [to work on the LMS].”

As presented above, one of the reasons for teachers’ lack of motivation to upload resources on the LMS is their anticipation that students wouldn’t use the platform as many of them have no access to computers. Another respondent attached the use of LMS to the student’s motivation and culture of technology use, and said:

> "Students, graduate students specially, like Telegram. That is it. We also create group e-mail and send materials through them [for graduate students]. Thus, the students don't want to use learning management systems. They don't want to log in the website. I don't know why. I think they like the social media because it is the easiest [to share content]."

A response from another participant highlighted why students shun the LMSs:

> "During COVID-19, our university made it mandatory for all instructors to upload content to the LMS. However, students were complaining saying that they couldn't find (access) the uploaded material because it takes them up to five clicks to reach the resources."

Another respondent said teachers consider LMS management as an additional task and require incentives to do so. Another participant said he simply prefers to share learning resources with his students via Telegram because his university's LMS is not user friendly, and he often forgets his passwords. There also seems a misunderstanding on the role of LMSs by the same participant as he said:

> "[The LMS] is to be used when you don't find students nearby. However, as I find my students nearby, I don't need to use the LMS. I prefer to share the resources via Telegram."

The other problem seems a lack of framework for LMS management. A participant who happened to be a college dean said:

> "We don't have such application in our college. It may be used in the other colleges. This thing, there was an initiative to use it ten years ago. I took training on the Moodle LMS. But I don't think anyone uses it in our college. Perhaps it is used in other colleges."

When asked about digital services available to persons with disabilities and whether there are efforts to produce learning resources in accessible formats, the same participant said

> "In our college? There is no such service. The reason I say "our college" is because this university is huge. You may expect differences between colleges in it. There might be colleges who use advanced inclusive technologies. However, as far as I know, I cannot be a hundred percent sure, there is no such service in our college. However, there is a disability center which is led by a director, and they have different technologies there. They have opened centers at two and three places at different campuses. Perhaps our instructors (teachers) are communicating with the center, I am not sure. Anyway, that center [the disability center] is resourceful."

An interviewee teaching in special needs department explained the process he used to send content to students with visual impairment:

> "When we prepare lesson materials, we prepare it in PDF format and send it to the disability resource center. There, they reproduce the materials with braille embosser and store them in the library or any other place where the

> students could access the materials. There are those who have access to JAWS [screen reader software]. JAWS is also installed on the computers the computer center designated for use by students with disabilities."

The interviewees said that the COVID-19 shutdown has provided opportunity to appreciate technology and get familiar with different instructional technologies. E-learning was attempted during the COVID-19 shutdown. Those participants who taught in postgraduate classes said they used tools, such as Zoom, Google Meet and Microsoft Teams. However, that was not done for undergraduate students. The main reason given was that most of the students are from rural areas where there is poor electricity and probably no Internet connection. Nevertheless, learning resources were uploaded for whoever can get access to the Internet. Crash courses were given to all students before they sat for exams after they came back to their universities. However, the interviewees felt that those who had access to the learning resources had a better chance of scoring good grades.

The other problem raised by the participants is undergraduates' the low-level usage of e-mail. A participant said:

> "Undergraduate? What I observed is that many of them don't use e-mail. There are students who don't have e-mails. There were undergraduate students who are enrolled to take part in summer classes. I felt to teach them via Google Meet and asked them to give me their e-mail addresses. Out of forty students, only ten of them had e-mail addresses. […] but the undergraduate students come from rural areas."

As discussed above, the universities included in this study have ICT infrastructures that require a better setup to improve their utilization. Lack of content due to financial constraints, teacher's reluctance to produce content, cultural aspects of ICT use by teachers or students, complicated LMS designs, low level of digital literacy, student's poor background, lack of local or national policy or guideline that streamlines content production and management are among the barriers explored. Those issues are elaborated with findings presented below.

5.2. Access to computers and ICT

Out of the total 418 students, 43% (n=180) said they have computers, 90% (n=318) said they own smartphones, and 7% (n=31) said they have tablets. 67% of those who owned tablets were from medical colleges. 5% (n=22) said they have neither computers nor smartphones. As learned from teachers during the interview sessions, the reason for more medical students owning tablets was the availability of a fund that allowed the medical colleges to provide their new students with tablets.

Student respondents (hereafter referred to as "respondents") who don't have computers were asked to state reasons why that was the case. The main reason given by those who were willing to share was related to the poor backgrounds they came from. Nevertheless, a response from one respondent showed poverty may not always be the case:

> "I mostly am dependent and feel comfortable with high-end smartphones and I use them instead of computers."

Respondents who don't own computers were asked how they accessed computers when the need arises. Out of the 221 who were willing to provide explanations, 24% said they used their smartphones, 22% said they used computer sections in university libraries, 22% said they would use computer rooms or labs in their departments, 10 % said they borrowed computers from their friends, and an individual said he goes to an Internet café. The data shows the importance of shared access facilities, such as computer labs and libraries to provide students access to computers. Their heavy reliance on smartphones also implies the need for working on educational resources which are mobile friendly.

Further analysis was done whether the urban-rural divide has affected students' ownership of computers. Out of the total 238 students who don't have computers, 42% (n=99) were from rural background, 28% (n=66) were from semi-urban background, and 30% (n=73) were from urban background (see Table 2). The data would show more students from rural areas not having computers. Nevertheless, the presence of rural students with computers would suggest against generalizing computer ownership by an individual's socio-demographic background.

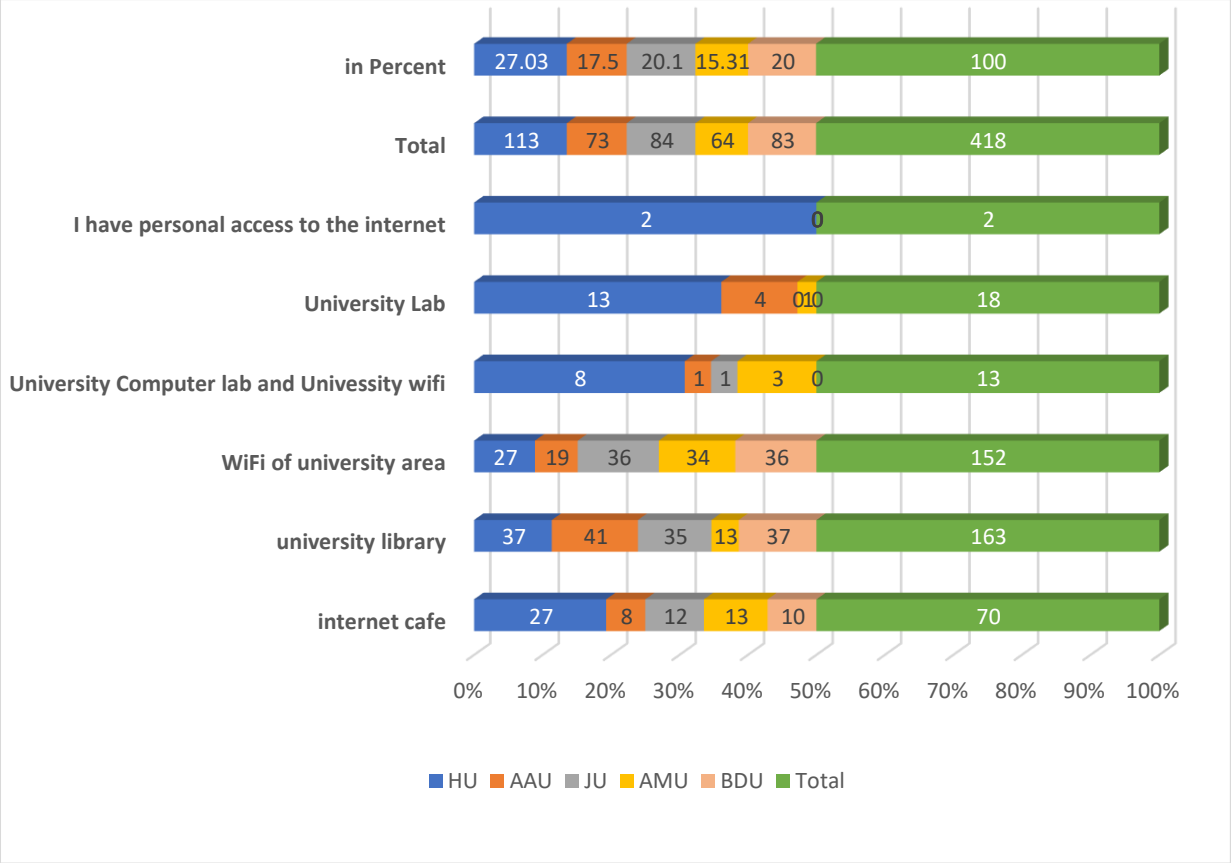
Table 2. Respondents' ownership of computers by residential background

Residence area			University Name					Total
			HU	AAU	JU	AMU	BDU	
Urban	Computer access	Yes	61	25	11	17	7	121
		No	13	14	13	19	14	73
	Total		74	39	24	36	21	196
Semi Urban	Computer access	Yes	12	10	7	4	6	39
		No	13	7	18	8	20	66
	Total		25	17	25	12	26	105
Rural	Computer access	Yes	7	7	4	1	1	20
		No	7	10	30	17	35	99
	Total		14	17	34	18	36	119
Total	Computer access	Yes	79	43	32	23	16	180
		No	33	28	49	44	65	238
	Total		112	71	81	67	81	418

Source: Survey data collected by the research team between April 1 of 2022 and May 7 of 2022.

The students were asked how they get access to the Internet. As shown in Figure 2, 39% (n=163) said they would use their university's library, 36% (n=152) said they use Wi-Fi hotspots in their universities, 17% (n=70) said they would go to Internet cafés, 4% (n=18) mentioned university computer labs, and 3% (n=13) said they would use computer labs and Wi-Fi hotspots, while two respondents said they have personal Internet accounts. The overall data shows students' dependence on shared access facilities to access the Internet.

Figure 2. Respondents' access to the Internet



Source: Survey data collected by the research team between April 1, 2022 and May 7, 2022.

The respondents were asked another question to know whether they use mobile data subscriptions. Ethio telecom offers mobile packages of different prices. The packages could be either unlimited (e.g., 1000 Birr per month to use for the whole month without limit) or limited packages which are available for different prices[11]. 80% (n=333) indicated that they have used limited packages.

5.3. Barriers of Access to ICT

The respondents were asked to detail barriers they faced in their access to ICT. 229 (52%) of them listed different obstacles they have faced. The responses are summarized and presented in Table 3.

Table 3. Barriers of Access to ICT

[11] https://www.ethiotelecom.et/package-offers/

Barriers	%
Lack of access to computers and ICT	18%
Problems with shared access facilities, such as computer rooms, Internet, campus Wi-Fi, etc.	52%
Poor Internet access	20%
Financial problems	27%
Poor digital skills	23%
Electricity interruptions	7%
Others	3%
No barrier faced	10%

Source: Survey data collected by the research team between April 1, 2022 and May 7, 2022.

Further analysis was conducted to see if the barriers relate to users' ownership of ICT devices. Out of 183 students who have both computers and smartphones, 20% (n=37) mentioned low Wi-Fi in the campuses as a problem. 7% (n=13) said there are insufficient number of computers in libraries and computer labs, 8% (n=16) complained about high Internet costs, 10% (n=18) mentioned slow Internet as a problem, 5% (n=10) mentioned electricity interruptions as barriers. Two respondents mentioned problems related to low level of digital skills. Two respondents with visual impairment mentioned accessibility barriers, such as the inability to see some part of a computer's screen, the inaccessibility of technologies for persons with disabilities and lack of personal assistants. Personal assistants are those who are hired to help persons with visual impairment in reading and recording content. 11 respondents (6%) said they have faced no barriers. 50% left the question unanswered.

Out of the 221 respondents who don't own computers (including 22 of them those who said they have neither a computer nor a smartphone), 20% (n=45) mentioned the weak Wi-Fi in the campuses as a problem. 17% (n=38) of them mentioned their inability to buy computers due to financial problems. 8% (n=18) discussed problems with libraries and computer labs, such as insufficient number of computers, "old" computers, poorly ventilated computer rooms, and opening hours that restrict access to the computer rooms. 14 respondents (6%) said Internet access is expensive, 4 respondents mentioned electricity interruptions as a problem. 14 respondents (6%) said they didn't face a barrier.

The paragraphs above show respondents with and without computers sharing similar problems concerning Internet cost, campus Wi-Fi hotspots and the number and quality of computers in libraries and computer labs. That points to the need of strengthening shared access facilities in universities for the benefit of all students regardless of whether they have ICT devices.

The data also showed respondents on either side (i.e., those who own computers and those who don't) who explicitly said that they haven't faced any barrier. That would imply barriers are not solely the result of whether individuals possess ICT devices or not, but also of their activities that require ICT usage and their level of usage.

5.4. Barriers for persons with disabilities

As mentioned above, there were a few students with disabilities who were included in the survey. Those students who don't have their own computers mentioned barriers,

such as financial problems to purchase computers and hire personal assistants, as well as digital illiteracy. A respondent wrote:

> "I have no computer. I am with disability and there is no one to help me [no personal assistant]. The university gave me only an audio recorder. Learning is difficult for me."

Lack of personal assistants was a problem mentioned by a respondent. Another respondent vaguely commented that technology is not accessible for persons with disabilities. An interview with a teacher who has visual impairment helped to clarify part of the problem saying:

> "When we use LCD [projector], we use ourselves instead of technology to describe what is on the presentation. If there is a picture, we describe the picture so that they can visualize it. What a regular student can see and understand, we are expected to explain that to students with visual impairment. Technology could have helped us. If I am not mistaken, there is what they call screen reader which can do that. If we can integrate that, it would make teaching-learning inclusive".

The above response implies the need to use accessibility guidelines[12] in producing digital documents so that the content could be read by screen reader technologies. The guidelines include techniques for producing alternative text for non-text content so that users with screen readers could understand what that object is about. Absence of such measures is a problem identified in this study.

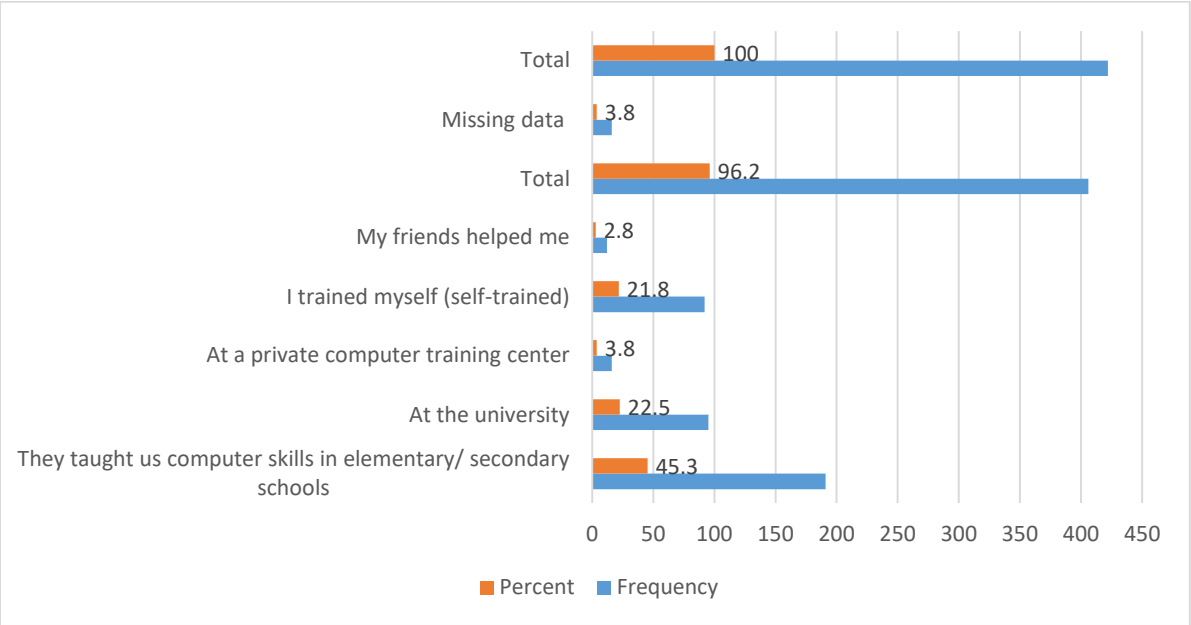
The other problem, especially for those with visual impairment is a mismatch between what they need and what is available. During the interviews, a participant explained a trend where there is an increase in the number of new students who don't know how to use braille. As the result, braille printers and accessories in disability centers are seeing reduced usage from time to time. At one of the universities included in this research, the university library has only braille books available for students with visual impairment, which would also be unusable for the new students. Thus, lack of content in an alternative format (e.g., audio, braille, etc) is a problem for students with disabilities.

5.5. Digital Literacy

From the interviews, it was learnt that universities have an expectation that new students are equipped with ICT skills as there are ICT courses in high schools. During the interviews, a participant though raised the possibility of students coming with just theoretical knowledge of what computers are, without sufficient hands-on experience. The students were asked about their background in ICT education. Figure 3 presents the answers.

[12] https://www.w3.org/WAI/WCAG21/Understanding/

Figure 3. Respondents' ICT skills acquisition



Source: Survey data collected by the research team between April 1, 2022 and May 7, 2022.

45% of the respondents indicated that they have taken ICT courses in high schools. 23% said they took computer courses at their universities, 29% said they trained themselves, 3.8% said they took training at a private computer center, and 3% said they were helped by friends.

As shown in the data, the notion of a fairly large number of respondents claiming to have trained themselves is supported by some interviewees. When asked about their opinion about their students' ICT literacy, an interviewee said:

> "I think there is a course at freshman level. They have a course on ICT. There would be a possibility that some students come from high school without touching a computer. However, children of this day have the ability to catch up if they are supported, wherever they may have come from."

Another interviewee said:

> "There is no ICT literacy course other than the course they take during their freshman year. It is believed that they learn ICT skills at high school. If there is motivation, the technology itself can guide you."

The notion of students training themselves would show their motivation to acquire digital skills. Nevertheless, the opinions as mentioned above would exacerbate the skill gap between students as there are varying levels of ICT literacy observed during the survey. For example, students were asked to discuss their experience of the e-learning conducted during the summer. The following responses were given by students of the same university, same department, and same year, and all from urban background:

> Respondent 1: "There was no e-learning hosted by our university."

Respondent 2: “My department wasn't providing online learning, but I was doing my own e-learning from other sources.”
Respondent 3: “There was no e-learning system.”
Respondent 4: “There was not enough e-learning material on the portal.”

The above examples exhibit the ICT literacy gap that exist among the students. As there are students that are not familiar with e-learning systems, there were others who were knowledgeable of other e-learning resources and use them to complement what they missed from their institution’s e-learning portal.

The questionnaire included an open-ended question for students to discuss the use of ICT resources that are specific to their profession. Only 11 out of the 418 respondents were able to answer that question. The applications listed included Academia, Amboss, Kiwix, Discord, MedShr, Lecturio, Google Class, Yander, and fintech applications. Most of those applications are mentioned by medical college students.

The data shows the need of digital literacy programs that aim not only to train students with basic skills but also to familiarize them with the available educational resources and technologies (including the open-source ones) in their professions. The following response from a teacher participant demonstrates the role of teachers.

> “I help my students by showing them free websites, giving them web addresses of open source urging them to participate in online programs, give them addresses of open-source websites, and show them how to use the Zoom application.”

Disparity in ICT skills was also noted among the teacher participants. On one hand, there are interviewees from ICT background who obviously are confident of their ICT skills. On the other hand, there are interviewees who said they have just the basic skills to use Microsoft Office products, convert documents to PDF, upload and download documents, and browse the Internet for resources. Nevertheless, it would be erroneous to attach teachers’ academic background with their use of LMSs. For example, two interviewees - one from engineering, and the other from medicine said they upload animations on LMSs. One of them said:

> “I upload text materials; some video lectures and assignments and every student can access it. I also upload animations. I give courses in mechanical engineering on how things work, and the students possibly understand only 30 or 40 percent of it during the lecture hours. So, I upload animations so that, when students download and watch them later, they could reach to 100% understanding of the lesson.”

As explained earlier, the COVID-19 shutdown was the period where the LMSs were relatively more active. As discussed in section 5.1, there were no real-time (synchronous) e-learning provided to undergraduate students. When responding to a question about whether they took part in e-learning courses during the shutdown, some students wrote answers that question their teachers’ competence. A student wrote:

> “There wasn't any e-learning program to participate in. They just gave us a bunch of files and told us to read them until we get back. Besides, there was limited access to Internet at that time.”

Another student wrote:

> “I bet our department lacks the know-how to conduct e-learning.”

To sum up, the data presented shows skill and knowledge gaps between students as well as between teachers. Teachers have a role to improve digital literacy of their students especially by introducing them to subject-specific applications and resources. In that sense, digital literacy of teachers is important to improve the digital literacy of students.

5.6. Use and Motivation to Use

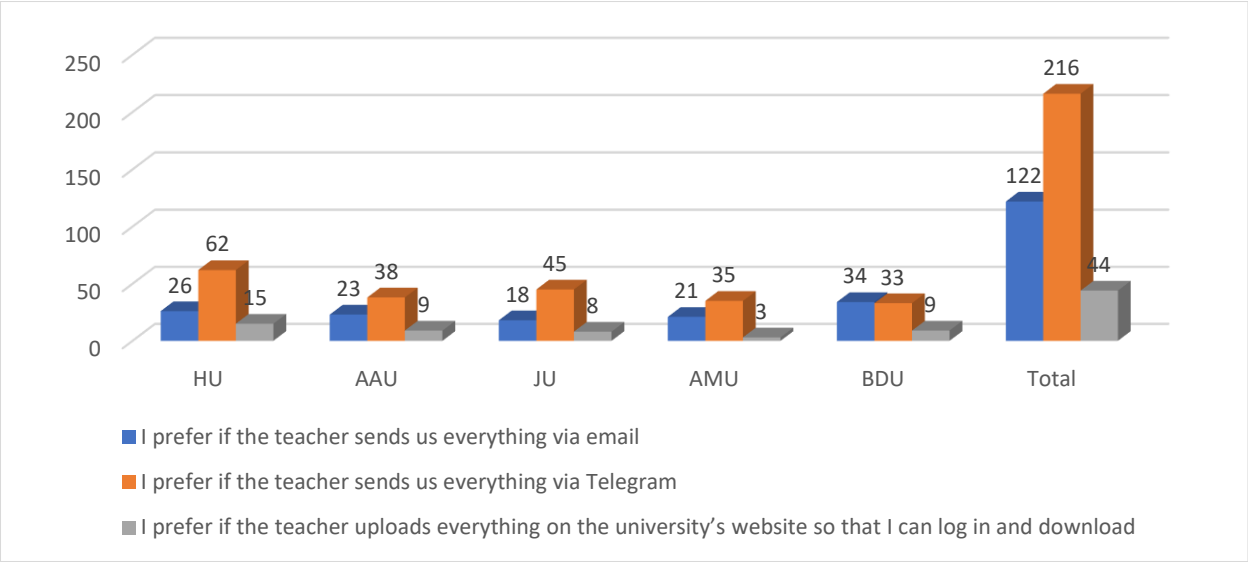
As discussed in section 5.3, there were respondents who don’t own computers, and who said that they haven’t faced any barriers. One of those respondents said he can use the computer labs in his university. When responding to a question about barriers, he wrote:

> “There is no barrier which hinders me from accessing and using information technology because there is good Wi-Fi in Jimma University.”

The above example would show that barriers are the function of participation and usage. Activities make usage necessary. More usage would increase the likelihood of discovering barriers. New barriers would exist when students are exposed to new technological applications. Digital literacy permeates usage, and usage would lead to discovery of barriers.

During the interviews, one of the complaints by the teachers was that the students have “dependency syndrome”, expecting everything to be sent to them by teachers. The students were asked to specify how they would like to obtain learning and learning materials. Figure 4 presents their responses.

Figure 4. Students’ preferred ways for obtaining digital reference materials

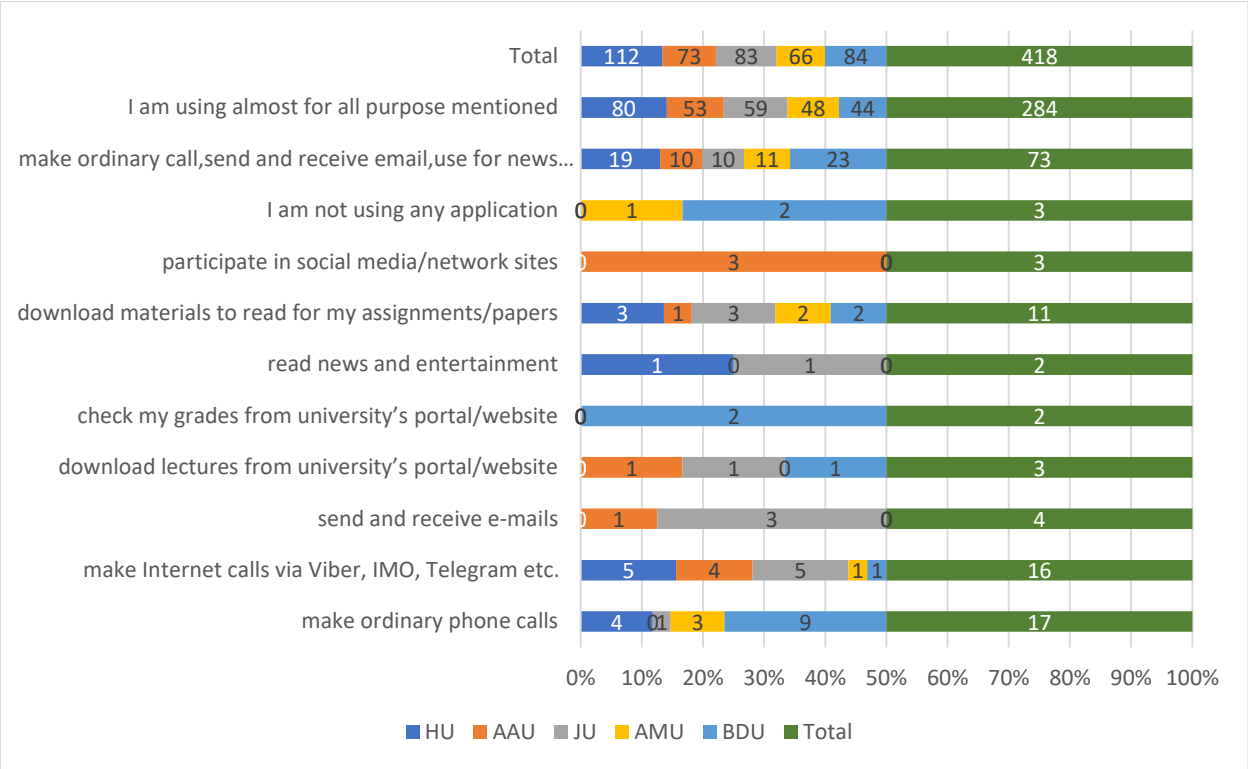


Source: Survey data collected by the research team between April 1, 2022 and May 7, 2022

The majority (52%) of students preferred if their teachers send them the materials via Telegram. 36% said they would like the materials sent via e-mail and 11% said they would like to login to university portals, check the materials from there and download the materials. Upon review of the data, it appears that students like the mechanism which requires the least interaction (e.g., Telegram).

As discussed earlier, most of the respondents use smartphones. A question was presented to understand the purposes for the use of these devices. Figure 5 presents the responses.

Figure 5. Respondents' use of smartphones



Source: Survey data collected by the research team between April 1, 2022 and May 7, 2022

Figure 5 shows that most respondents (68%) use their smartphones for almost all of the activities shown in the chart. Besides that, the devices are used mostly for social media applications and the least used for educational purposes such as downloading lectures from university portals.

The interviews (see section 5.1) and the data presented a great deal of non-use of even the available ICT services. Usage of a resource justifies the investment made. Teachers' reluctance to upload content to LMSs was linked to their perception that students won't use the LMSs (see Section 5.1), and students' reluctance to use LMSs emanates from the perceived complexity of the system. Thus, it would be important to ask what motivates students to use the ICT services.

We attempted a statistical analysis based on four point Likert scale on the responses of students' digital skills, ICT use for personal purposes, ICT use for educational purposes, and students' view of ICT use in education to understand what motivates students to use ICT for educational applications. As shown in Table 4, a correlation analysis conducted on the data showed strong correlation (r=.547, P<.05) between learners' ICT skill level and their ICT use for personal purposes. However, the correlation between students' view of ICT use in education with their ICT skills (r=.145, P<.05) is at a weak level. Moreover, there exists a strong positive correlation (r=.733, P<.05) between ICT use for personal purpose and use ICT for educational purpose. This could be because, as discussed earlier, students use social media applications, which they use for personal purposes (such as Telegram) for educational purpose too.

Table 4. Correlation analysis of digital skills, ICT use for personal use, ICT use for education purpose, and students view of ICT use in education

		Digital skill	ICT for personal use	ICT use for Education purpose	Students' view ICT use for Education purposes
Digital skills	Pearson Correlation	1	.547**	.571**	.145**
	Sig. (2-tailed)		.000	.000	.003
	n	418	418	418	418
ICT for personal use	Pearson Correlation	.547**	1	.733**	.170**
	Sig. (2-tailed)	.000		.000	.000
	n	418	418	418	418
ICT use for Education purpose	Pearson Correlation	.571**	.733**	1	.209**
	Sig. (2-tailed)	.000	.000		.000
	n	418	418	418	418
Students view of ICT use for Education purposes	Pearson Correlation	.145**	.170**	.209**	1
	Sig. (2-tailed)	.003	.000	.000	
	n	418	418	418	418
**. Correlation is significant at the 0.01 level (2-tailed).					

Source: Survey data collected by the research team between April 1, 2022 and May 7, 2022

Table 5. Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.764[a]	.584	.580	.47454

a. Predictors: (Constant), digital skills, ICT for personal use, students' view of ICT use for Education purposes.

b. Dependent Variable: ICT use for Education purposes

Source: Survey data collected by the research team between April 1, 2022 and May 7, 2022

Table 6. ANOVA table: shows the extent how the model fits to predict the variables at P<.05

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	130.926	3	43.642	193.806	.000[b]
	Residual	93.452	415	.225		
	Total	224.378	418			
a. Dependent Variable: ICT use Education purposes						
b. Predictors: (Constant), digital skills, ICT for personal use, students view of ICT use for education purpose						

Source: Survey data collected by the research team between April 1, 2022 and May 7, 2022

The model summary presented in Table 5 describes the calculated correlation coefficient R which shows the contribution or relationship between each independent variable and the dependent variable. We must first verify the combined contribution of the independent variables to learners' use to ICT use for educational purposes in order to construct a regression equation and predict the effects of each variable. To this end, R=0.764 shows that there exists a strong positive relation between the variables in Table 4. R-square and adjusted R-square are close to each other at 0.584 and 0.580 respectively. That indicates that the independent variables account (predict) for 58.4 percent of the variability of the dependent variables. It was discovered that the Durbin-Watson=1.379 was between 1 and 3, indicating that the errors are minimal. Additionally, the model as shown in ANOVA table 6 with F- test=193.806 and P <.05 indicates that the regression model fits and is good to predict the independent variables (ICT for personal use, digital skills, and students' opinions on ICT use in education) on the dependent variable (ICT use for education purposes).

Table 7. Multiple regression analysis of students' digital skills, ICT for personal use, students' view of ICT use in education, and students' use of ICT for education purpose

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.023	.163		-.201	.041
	Digital Skills	.192	.031	.237	6.244	.000
	ICT for personal use	.654	.042	.590	1.504	.000
	View of ICT use for Education	.107	.046	.075	2.328	.020
a. Dependent Variable: ICT use 4Educationpurpose						

Source: Survey data collected by the research team between April 1, 2022 and May 7, 2022

In the regression table (Table 7), the p-value tests for each predictor is P<.05. This shows that each independent variable helps to predict how much students' use of ICT for educational purposes could be improved. Thus, in Table 7, students' digital skills significantly increased their use of ICT for educational purposes by .192, and students' personal use of ICT increased their motivation to use ICT for educational purposes by .654. Additionally, students' view of ICT uses in education positively contributed to their ICT use for education by .107.

From Table 7, one can establish the expected regression equation that predicts the students' current use of ICT use for educational purpose as:

Ÿi =β0+β1Xi1+ β2Xi2+ β3Xi3+ εi----------equation 1 (predicts the influence of independent variables in one hour's time).

Where;

Ÿi dependent variable (StudentsICTuse4education) or student's ICT use for education purpose

β0, β1, β2 and β3are called regression coefficients of independent variables,

β0 is called intercept /constant,

β1 is called coefficient of Xi1/ students' Digitalskills;

β2 is called coefficient of Xi2/ ICT4personaluse;

β3 is called coefficient of Xi3/ view_OfICTuse in education;

εi is random error;

Hence, Ÿi =β0+β1Xi1+ β2Xi2+ β3Xi3. if εi=0----------equation 2 reduced to

Ÿi=β0+β1Xi1+ β2Xi2+ β3Xi3 ----------equation 3

Ÿi=f(StudentsICTuse4education_per_hr)=1.023+0.192*Digitalskill+0.654*ICT4personaluse+ 0.107*Stsview4ICTuse ----------equation 4

Therefore, the possible regression equation is:

Ÿi=f(ICT_use_4Eduation_purpose_per_hrs) = 1.023 + 0.192*1hr+ 0.654* 1hr+0.107*1hr ---------equation 5

Thus, from equation 5, Ÿ=f(sts_ICT_use_4education_purpose) =1.976, which means that if students are motivated to spend one hour a day in using ICT for educational purposes, they will have a possibility to improve their academic standing by 1.976. That means they would have time to browse and use educational applications which eventually could positively affect their academic standing. Therefore, the aggregate regression values of independent variables presented above predict the degree of students' motivation to utilize ICT for educational purposes.

6. Discussion

This study began with the purpose of identifying existing digital divides in Ethiopian higher education and to recommend solutions for bridging them. To that end, the following questions were asked: 1) What are the digital resources available and how are they being used to support the teaching-learning process? 2) How was the universities' ICT capability used to support education during the COVID-19 pandemic? 3) How is the current setup of the digital ecosystem in relation to digital inclusion? 4) What are barriers to connectivity and access to digital resources? The results presented in the preceding chapter answered the questions. This chapter discusses the results by identifying factors that would help to realize digital inclusion in Ethiopian HEI.

6.1. Inclusive and Resilient ICT Infrastructure

E-learning, LMSs and digital libraries are just a few examples of applications which are made possible through ICT. ICTs also create a platform for better communication and collaboration between students, and between students with teachers, helping them to realize a resilient educational system that could withstand disruptions that make a face-to-face instruction unattainable (Batista et al., 2021). Nevertheless, there could be a risk of inequality if the digital divide is not well-addressed. This research highlighted two major issues that need tackling to overcome the digital divide: access and accessibility. The concept "access" signifies having access to ICT whereas the concept "accessibility" connotes the ease with which students, including those with disabilities, interact with ICT services (World Wide Web Consortium (W3C), 2016).

6.1.1. Access

The major obstacle for equitable access to ICT identified in this research were students' inability to afford computers and Internet connection. The presence of shared access facilities, such as computer rooms and Wi-Fi hotspots in the universities helped to mitigate the problem. Nevertheless, the insufficient number of computers in computer rooms, weak Wi-Fi signals, limited opening hours of computer rooms were among the problems mentioned by the respondents (See Table 3). Thus, adding more computers and Wi-Fi hotspots would strengthen the shared access facilities for better ICT access. Other studies also recommended similar solutions (Barnard & Merwe, 2015).

Trends in higher education, such as e-learning, blended learning, and their increased popularization by the COVID-19 situation required universities to think about their students' off-campus access to ICT. Loaning laptops to students, giving tablets to students were some of the measures taken by different HEIs, with university libraries being responsible for long-term laptop loans for students (Archer-Helke et al., 2021; Rice & Cummings, 2020). Moreover, collaborations with Internet service providers to offer discounts to student was a solution to enable affordable Internet access (for e.g., Barnard & Merwe, 2005). As shown in this present study, education was disrupted mainly for undergraduate students because most students came from areas which were not well connected to the Internet. Moreover, most of the students don't own computers (see Section 5.2). The examples presented above could be used to enable Ethiopian universities to help their students' on-campus as well as off-campus access to ICT. However, it should be underlined that ensuring equitable and affordable access to students is not a sole responsibility for HEIs. It requires collaboration and coordination of different stakeholders. For instance, a report by the Internet Society (Internet Society, 2021b) documented how local residents in a town in Zimbabwe set up a cybercafé, which was later transformed into an Internet powerhouse that acts as both a resource center and an information hub serving workers, school officials, parents, students, business people, and residents in the district. Another story from the Internet Society (2021a) discussed how the Internet Society and the Digital Empowerment Foundation joined forces to implement the Wireless for Communities initiative and to establish a community network in a rural Indian town to provide connectivity and digital literacy trainings. Thus, local authorities could encourage collaborations to establish such community hotspots that would open opportunities for e-learning and other digital services.

In this present study, it was discussed that most undergraduates have rural background which potentially could have limited their ICT experience. This would demonstrate that digital inclusion in education is not a venture that should begin when students join universities. It requires a long-term investment that starts from lower schools (UNICEF, 2020). It is also an undertaking that requires collaboration between different governmental and non-governmental entities (Clayton & Macdonald, 2013).

6.1.2. Accessibility

Three of the five universities included in the present study have separate computer rooms for students with disabilities. It was observed that there were computers with screen readers and Braille embossers in the rooms. The advantage of such scheme could be the presence of personnel dedicated to help students with disabilities. A problem identified during the study was the likelihood of a mismatch between what is available and what users require, especially with increasing number of students who haven't learned Braille.

Schools may opt to either prepare separate computer rooms for students with disabilities or apply the principles of inclusive design in existing computer rooms. Inclusive design is a concept for making products and services accessible to all to the extent possible (Joyce, 2022). A simple step could be to situate computer rooms at the ground floors where they could be easily accessed by all students. In either case (i.e., specialized and inclusive design), it would be important to take students' needs and preferences into consideration. For instance, a student with visual impairment may

not be able to use a computer without an assistive device. Depending on the type of visual impairment (e.g., blindness, low vision, color blindness, etc.), the student would require braille keyboard, screen readers, screen magnifiers and other devices which would facilitate his/her interaction with a computer. A student with motor impairment could be helped by gesture recognition tools that enable interaction with user interfaces via hand or eye movements (Ertugrul et al., 2020; Kakkoth & Gharge, 2018). A student with speech impairment would need voice output devices to make verbal communication. These examples demonstrate the importance of understanding students and their needs, and the available technologies that may facilitate their access to ICT.

6.2. Accessible Content

There are two approaches for making educational resources accessible. The first is to produce content in alternative formats, such as Braille, audio recordings, text documents so that students can choose the format that suits them best. The other is to use accessibility guidelines while designing digital content so that regardless of the format used (e.g., text, graphic, audio, video), the content could be accessible to all (Douce & Porch, 2009; University of Washington, 2012). For instance, according to WCAG[13], adding alternative text to a picture enables screen reader users to know what the picture is about. Adding magnification options on websites could be helpful to those with low-vision impairment. Adding captions to videos makes the videos usable for persons with hearing impairment. Such guidelines, therefore, could be used to make digital content accessible to all students to the extent possible.

A major problem with the universities covered in the present study was that content accessibility was not addressed except for the production of course materials in Braille form and provision of recording devices for students with visual impairment. The other problem is the lack of knowledge of digital accessibility and accessibility guidelines. Therefore, it is safe to assume that accessibility guidelines were not used while producing the universities' digital collections, which are mostly comprised of research works by students and university teachers.

As presented in section 5.1, disability centers are responsible for the production of lesson materials in braille format. It would be a good step towards digital inclusion if such centers are scaled up to produce accessible educational materials in text (e.g., HTML, PDF, EPUB), audio, and video formats. Copyright issues may hinder the reproduction of text materials in an alternative format. Nevertheless, provisions in the Marrakesh Treaty (World Intellectual Property Organization, 2013) allow reproduction of text content in alternative formats (e.g., audio) for the print-disabled. Print disability is the inability to read text materials due to perceptual, physical and visual impairments (Blansett, 2008). The disability centers would also require expertise in technical guidelines, such as the WCAG, Instruction Management Systems (IMS) Global guidelines[14], Microsoft accessibility guidelines[15], and guidelines from Adobe[16] to advise faculties and ICT departments on the use of such guidelines during content

[13] https://www.w3.org/WAI/WCAG21/quickref/#audio-only-and-video-only-prerecorded
[14] https://www.imsglobal.org/accessibility/accessiblevers/sec5.html
[15] https://support.microsoft.com/en-us/office/make-your-word-documents-accessible-to-people-with-disabilities-d9bf3683-87ac-47ea-b91a-78dcacb3c66d
[16] https://helpx.adobe.com/acrobat/using/create-verify-pdf-accessibility.html

production and web design. Thus, disability centers need to be well-staffed with manpower of technical and legal expertise so that they could be digital inclusion centers of their universities.

As discussed in the preceding chapter, teachers often point to disability centers when asked about whether their course materials are accessible to students with disabilities. Nevertheless, it would be important to underline that teachers have a role in digital inclusion. As an example, the Universal Design for Learning framework (UDL) could be used to show the roles teachers could play. UDL is a framework for creating a learning environment that accommodates the diverse needs of learners, providing them with flexibility in the ways they access and use learning resources (Stapleton-Corcora, 2022). Diversity may be expressed in terms of learner's disability/ability, language, economic, cultural, or socio-demographic background. With digital learning becoming a new normal, accommodating learners' diverse needs as specified by UDL becomes crucial (Nolasco, 2022; Snelling, 2020). That makes the production of accessible resources a responsibility that teachers need to share.

Accessibility is not solely about students with disabilities. It is also about addressing students who could have different preferences on how the content is presented to them. For instance, this present study showed that the students' use of smartphones could be a matter of preference for some of them. That would suggest designing LMSs, digital libraries or other content management systems to be mobile-friendly. Part of the reason that students as well as teachers avoid LMSs was attributed to the navigational burden, i.e., excessive links they have to click on to reach to a certain material. Other studies confirmed that such complexity discourages students from using LMSs, digital libraries and repositories (Beyene, 2016).

Accessibility of digital content, therefore, includes production of educational materials in accessible and alternative formats to suit the needs of diverse groups of students. It also includes the design of websites, portals and other user interfaces in a way that simplifies access to digital content.

6.3. Digital Literacy

This research revealed that the available ICT services, except for some basic services (e.g. Telegram and a limited use of e-mails to communicate and share content), are underutilized. Digital literacy is identified as a major factor that could have affected the use of educational ICT services (see section 5.6).

UNESCO defines digital literacy as "the ability to access, manage, understand, integrate, communicate, evaluate and create information safely and appropriately through digital devices and networked technologies for participation in economic and social life."(Antoninis & Montoya, 2018). Digital literacy includes computer literacy, ICT literacy, information literacy, and media literacy (Antoninis & Montoya, 2018; Leaning, 2019). Information literacy is understood as the ability to find, evaluate, organize, use and communicate information (American Library Association, 2015). Media literacy could be understood as the ability to find, analyze, evaluate and produce information in different formats for different outcomes (Botturi, 2019; UNESCO, 2022). Thus, a way to evaluate the digital literacy level of an individual is to see which of those literacies he/she possesses.

Using the above definitions as a frame of reference, it is possible to see that the participants of this present research are on different levels of digital literacy. On one hand, there are teachers who are not active in uploading lesson materials on LMSs. On the other hand, there are teachers who have uploaded multimedia contents and gave their students links to freely available resources on the Internet. Thus, a lack of digital literacy (e.g., media literacy) could have contributed to the lack of content in alternative formats (except Braille) and the apparent lack of knowledge of accessibility guidelines (see section 6.2). The situation is similar with the students, with some of them lacking the very basic computer skills, while others are on the other end of the spectrum and are familiar with the available digital resources, such as applications and e-learning sites, in their fields of study.

As discussed in section 5.1, universities expect new students to enter universities equipped with digital skills. However, given the students' diversity (e.g., rural background as against urban background, private school as against public school, etc.), it would be unreasonable to expect digital literacy in the manner defined earlier. Therefore, it would be important to develop a strategy for developing students' digital competencies ranging from basic computer literacy to information and media literacy in collaboration with disability/inclusion centers, libraries, IT departments and others involved in content and IT management. Tools such as the UNESCO's teachers competency framework (UNESCO, 2017) and ITU's Digital Skills Toolkit (ITU, 2018) could be used as references.

The existing Continuous Professional Development (CPD) program could be used as an opportunity to include digital literacy trainings for teachers. In the Ethiopian context, CPD is a pre-service and in-service teacher training program aimed at teachers' capacity building (Taddese and Rao, 2021). Teachers could play a leadership role to promote digital literacy among students by promoting the use of digital resources. For instance, they may search the Internet for freely available content that relate to their courses, evaluate the resources, and recommend them to their students. They could also promote the use of LMSs, digital repositories and libraries in their universities.

Digital literacy includes the ability to evaluate and harness the available technologies to conduct synchronous as well as asynchronous e-learning. In this research, Zoom, Microsoft Meeting, and Google Meet were mentioned as technologies used during the COVID-19 pandemic. Other studies have mentioned the use of television and radio especially to reach areas which are not connected to the Internet (Abrishamian & Feki, 2021). Notwithstanding the benefits such technologies present, problems, such as lack of social interaction, lack of discipline, difficulty to maintain classroom management, fatigue, eye sight problem, cognitive load are often mentioned in connection with online learning (Akhter et al., 2021; Bailenson, 2021). Educators, therefore, should be able to evaluate existing e-learning technologies and select those that better suit the needs of their learners. Criteria, such as user-friendliness, interactive features, size, ease of integration with LMSs, safety and security are examples that could be used during the evaluation (Agbejule, 2021). In summary, teachers' digital literacy should be developed to the extent that they can evaluate the available ICT applications and decide on which, when and how to use them.

6.4. Usage and Motivation

Having access to ICT won't ensure digital inclusion unless digital services are used by the intended users. Motivation is an important factor because people may not use technology unless they are convinced of its benefits to them (Clayton and Macdonald, 2021). The fact that some responders who do not own computers or smartphones said that they haven't faced barriers (see section 5.4), shows that "barrier" is a relative phenomenon. Barriers are discovered in the act of usage. The more people use ICT, the more is the possibility that they face barriers. The less they use ICT, the less included they will be. Thus, people have to be motivated to use ICT.

Schools' culture around ICT would affect motivation to use ICT (Marcinek, 2014). As evidenced in the present study, the "dependency" tradition where students expect their teachers to send them "everything" would limit students from exploring additional sources of information and independently develop their knowledge. Moreover, teachers' perception of their students' low ICT usage and their view of LMSs as an additional workload would limit the use of educational ICT applications.

This present study identified accessibility, usability, ICT culture, and digital literacy as factors that affect motivation to use ICT. For instance, it showed that students as well as teachers prefer technologies that require the least interaction. That would explain why Telegram is the most used tool for communication and content sharing (see section 5.6). The study also showed that login requirements may frustrate teachers as well as students from using university digital resources in their universities. A way to motivate them could be adopting a campus "one card" system that allows access to all services with a single login. Moreover, tackling accessibility and usability issues as discussed in sections 6.1, 6.2, and 6.3 would contribute to the removal of frustrations that affect motivation.

Some other factors of motivation are discussed in related literature. For instance, Trujillo-Torres et. al. (2020) listed teaching practice, availability of ICT resources in schools and at home, and age as factors that influence teachers' motivation to use ICT. Schulz et al. (2014) presented them as human factors (e.g., teachers' perception and opinion of ICT tools, teacher's ability to integrate technology in the learning-teaching process, and teacher's interest) and technology factors (e.g., usability, interactivity, adaptability). Shanmugam and Balakrishnan (2019) indicated that the prospect of scoring better grades would motivate students to use ICT.

The overall discussion made above shows that ICT use and motivation are intertwined with digital literacy and availability of ICT services at school and at home. Thus, the first step would be to resolve the access, accessibility and usability issues. That would create a favorable ground to either intrinsically or extrinsically motivate students and staff to use the services. Examples of extrinsic motivation would include requiring the use of campus e-mail to access all university ICT facilities, requiring students to use LMSs to access course materials and upload assignments, and limiting the role of social media in content sharing. That could be aided by university's ICT policies and guidelines. Digital literacy could be used to induce intrinsic motivation by demonstrating how ICT could help students in their studies. Vinther and Lauridsen (2022, p, 268.) underlined that intrinsic motivation is the "strongest motivational drive".

Thus, digital literacy programs that target intrinsic motivation would benefit students not only in their studies but also in their lives and careers.

6.5. Policies and Guidelines

Policies help to create institutional norms for inclusive use of technology to support the teaching-learning process. The policies could be used as references to develop institutional guidelines and to designate roles and responsibilities for teachers, colleges, libraries, computer labs, disability centers and others who are involved in the teaching-learning process.

Digital inclusion policies could be inspired by international conventions such as the Convention for the Rights of Persons with Disabilities (CRPD)[17] and other country-specific anti-discrimination laws. Then, an important step would be to identify all forms of digital divide and adopt a broader definition of digital inclusion. As discussed in this paper, the policies have to target all types of digital divides that affect the meaningful use of ICT.

A major problem identified in this study was the lack of, or non-use of, consistent policies and guidelines that govern digital content and educational technology management. There was an improvement in the use of technologies during the COVID-19 shutdown when e-learning was attempted. The findings, however, reflect the absence of a mechanism to monitor whether the practices have continued after the resumption of the regular classes. The interviews revealed inconsistencies and differences in the use of technology among departments and teachers. This implies the need for a digital inclusion policy which is adhered to by the academic community.

The way governments perceive and define digital inclusion determines the breadth and depth of interventions they would make to realize it (Clayton and Macdonald, 2013). It would also influence their ICT policies and subsequently the guidelines that would be formulated by HEIs. A digital inclusion policy, therefore, would be productive if it is supported by evidence (Helsper, 2014). The findings in the present study presented evidence on what policy makers can focus on: inclusive ICT infrastructure, accessible content, digital literacy, and use of ICT resources.

First, the policy can provide specific guidance for expanding on-campus and off-campus access to ICT resources and ensure that the needs of vulnerable groups such as students with disabilities and those from low-income background are met. As discussed in the preceding sections, steps to overcome those barriers would include strengthening shared access of ICT services in HEIs, establishing community centers such as libraries as ICT resource centers (Reed & Thompson, 2021), and facilitating the creation of community networks. Community networks are infrastructures which are built and owned by communities in areas where there is no commercially available network (Association for Progressive Communications, 2020). Thus, a digital inclusion policy would need to consider the need for intersectoral collaborations between HEIs, government agencies, local communities and non-profits to institute inclusive ICT infrastructures.

[17] https://www.un.org/development/desa/disabilities/convention-on-the-rights-of-persons-with-disabilities.html

Content is another major problem explored in this study. Digital content (e.g., journals and eBooks) from commercial vendors is too expensive for universities in developing countries (Mueller-Langer et al., 2020). This would contribute to the digital divide between universities in developed and developing countries, which subsequently contributes to a gap in educational quality between the universities. There have been initiatives such as Research4Life[18] which aimed to close the access gap by offering electronic resources for free, or at reduced rates to universities in developing countries. Ethiopian government universities have access to the journals available through the Research4life initiative. In addition to that, there is content produced within the universities. A digital inclusion policy could include guidelines for content acquisition, production, management, and use. Moreover, it would require a provision for the application of accessibility standards to make content accessible to all. A mechanism for content sharing could be established especially among the government universities. That would involve technical measures such as the creation of federated content databases that allow search and retrieval from anywhere the user is.

Digital literacy needs to be an important component of a digital inclusion policy. Defining it in a way discussed in this paper would help to specify what digital literacy entails.

7. Conclusion

Digital inclusion is crucial to ensure equal access to educational technology. Digital inclusion is also crucial to realize a resilient education system which ensures that no one will be disadvantaged in the event when face-to-face instruction becomes inconvenient. A review of relevant literature showed that the digital inclusion discourse in Ethiopia is mainly focused on the access aspect, i.e. expansion of Internet connectivity in the country. Moreover, the issue of content accessibility has yet to be addressed. This research attempted to fill the gap by conducting a holistic exploration of the digital divide in Ethiopian HEIs, emphasizing the accessibility of educational content, and presented ideas that could inform future digital inclusion efforts.

This research conducted on five Ethiopian universities identified structural, organizational and personal issues that a digital inclusion endeavor has to tackle. The structural problems relate to the overall situation in the country where students come from different socio-economic backgrounds. The inability to afford computers, a lack of proper ICT education at lower schools, and a lack of Internet connectivity in rural areas are examples of the structural problems. Organizational problems relate to the universities' overall ICT and content management strategy, inconsistent practices in the use of educational technologies, such as LMSs, inconsistent approaches in addressing students' lack of ICT devices (e.g., where some departments hand out tablets to their students while other departments don't), shortage of computers in computer rooms, poor Wi-Fi signals, shortage of digital content, and lack of content in alternative formats (except in Braille). Personal problems relate to individuals' low level of digital literacy, and their lack of motivation to use ICT services (except the social media) for communication, collaboration and resource sharing.

[18] https://www.research4life.org/

A strategy to overcome the above-mentioned barriers needs to consider the following: first, establishing an inclusive and resilient ICT infrastructure that ensures on-campus and off-campus access to educational resources needs to be the goal. That includes assistive technologies which increase independence and digital inclusion of students with disabilities. Second, the emphasis needs to be given to content development and management by addressing students' diverse needs and preferences. Production of educational content in alternative formats and application of accessibility guidelines could help to address diversity and inclusion. Taking the popularity of smartphones into consideration, it would be advisable if the digital services such as LMSs and digital libraries are mobile-friendly. Third, digital literacy is a broad topic that includes computer literacy, ICT literacy, information literacy, and media literacy. University ICT centers, libraries and disability centers could coordinate and plan to undertake digital literacy programs. It would be beneficial if the ongoing CPD program includes digital literacy trainings. Teachers' digital literacy contributes to students' digital literacy as teachers could use their position to promote the meaningful use of ICT resources by their students. Lastly, it would be important to have a digital inclusion policy that incorporates the concerns discussed above to establish consistent digital inclusion and inclusive design practices.

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