Digital Divide and Digital Barriers in Distance Education during COVID-19

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Abstract

Digital divide exists between the underserved student population and their peers, yet our knowledge about digital barriers and digital divide in distance education remains limited. In this study, we examine digital divide and digital barriers in distance education in the context of the coronavirus pandemic (COVID-19) by addressing two questions: (1) What digital barriers are emerging in distance education during COVID-19? (2) Do underserved students experience digital barriers differently from their peers? Informed by distance education and digital divide literature, this study uses qualitative research method to analyze survey data collected from 206 college students in a four-year public university in the United States. Results revealed five major digital barriers and showed that the distribution of these digital barriers varied by demographic background and socioeconomic status of the students. Practical implications are provided to educators and policymakers to implement equity-minded teaching practices and enhance digital inclusion of the underserved student population in distance education.

1. Introduction

The advancements of the Internet and information and communication technology (ICT) have enabled distance education, where teaching and learning take place online through network technologies. Yet, organizations continue to face challenges associated with technical expertise and infrastructure in achieving effective learning outcomes from their online learners [1]. With the widespread impact of the current coronavirus pandemic (COVID-19) on college education and with classes being increasingly moved to alternative modes (i.e., online, distance learning), we are facing a new normal characterized by the omnipresent and increasing assistance of information technology. With more than 1.2 billion students in 186 countries affected by school closures in spring 2020 due to COVID-19 [2], the barriers in online learning that are not found in in-person instruction are becoming more evident. Now, more than ever, enhancing college students' access to technology resources and improving their digital competence have become essential to their learning outcomes and college achievements at times of the global crisis.

Among the populations of students switching to online learning platforms in response to COVID-19, underserved minority students were experiencing a higher level of difficulty and lower level of technology readiness [3, 4]. An underserved student population is one that lacks resources to facilitate digital inclusiveness for low-income students, racial and ethnic minority students, and first-generation college students (FGCS). In particular, FGCS go into their college life with no one leading the way (e.g., parents) or having had any pre-exposure as to what to expect as a new college student. Many do not understand the technology requirements for course instructions and fail to identify support systems. Research has found that FGCS are twice as likely to leave college without a degree [5]. Thus, when technical resources and digital skills are essential to distance education, lacking such resources and skills may leave FGCS feeling beaten and overwhelmed in the online learning environment, compared to in-person instruction at schools and universities. In this regard, understanding their barriers in online learning has become an important step to achieving digital inclusion in distance education.

We define digital inclusion in distance education as utilization of information and networking computing capabilities to participate in learning activities; it can be measured by the level of access to and proficiency in ICT. Our definition is consistent with prior research [6, 7]. As digital inclusion focuses on the degree of having access to and utilizing technologies, it is closely related to digital divide, which focuses on the gap in technology access and use, i.e., information Haves and Have Nots, the question of access, and universal service [8]. In the United States, even as many aspects of the digital divide have narrowed over time, the digital lives of

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lower- and higher-income Americans remain different. According to a recent Pew Research Center report, more than four-in-ten don't have home broadband services (44%) or a traditional computer (46%). Roughly three-in-ten adults with household incomes below $30,000 a year (29%) don't own a smartphone. In comparison, each of these technologies is nearly ubiquitous among adults in households earning $100,000 or more a year [9]. Prior to COVID-19, those without Internet access used to fill the gap by using free Internet access in public libraries or public WiFi at coffee shops. During COVID-19, the digital divide became evident in schools' sudden transition to online learning platforms. The mandate of social distancing makes it virtually and physically impossible for students using libraries to fill the gaps in Internet access, at least in the short term [4].

As the pandemic situation evolves, it is important for higher educational institutions to understand the barriers to online learning, especially digital barriers experienced by students, in order to adapt to students' needs and support them in achieving academic continuity during the times of crisis. However, our knowledge about digital barriers and digital divide in distance education remains limited. To fill this gap, this study examines digital divide and digital barriers in distance education in the context of COVID-19 by addressing two questions:

(1) What digital barriers are emerging in distance education during COVID-19?

(2) Do underserved students experience digital barriers differently from their peers?

Answers to these questions will reveal specific types of technological resources and support urgently needed by underserved college students during their transitions to online classes under COVID-19 and to improve digital inclusion in the online learning environment. To achieve our research objectives, we review literature on distance education and digital divide to inform our data analysis and interpretation of results. Our study revealed five major digital barriers by analyzing qualitative data collected from 206 respondents at a four-year public university in the United States. Moreover, we found that the distribution of these digital barriers varied by the ethnic background and economic status of the college students.

Our study highlights the importance and urgency for educational institutions to pay attention to economically and ethnically diverse students to understand their learning needs so as to better help them engage in the online environment and assist them in achieving their academic goals. Findings of this paper can make an immediate impact by providing practical implications and guidelines to educational institutions when they continue to adopt distance education in the 2020-2021 academic year and beyond.

2. Literature Review

This section provides a focused review of the existing studies on distance education and digital divide, two key concepts of this study. Specifically, we discuss the definitions of the concepts, the benefits and barriers of distance education, and the influencing factors of digital divide, which help us identify the research gap and assist in the analysis and interpretation of our data.

2.1. Distance Education

Distance education is one of the most powerful responses to the growing need for education in the digital society today [10]. Following Zhang et al. [10], we define distance education (also referred to as "online education") as involving teaching and learning online through network technologies.

Distance education provides numerous benefits to learners. For example, through computer-mediated communications, students in distance education have the flexibility to perform learning activities at their preferred time, location, and pace. According to Hrastinski [11], electronic media such as e-mail and discussion boards facilitated asynchronous online learning, which provides flexibility to learners as it allows them to log on to an online learning environment and download documents or send messages to teachers or peers at any time. Meanwhile, electronic media such as chat and videoconferencing supported synchronous online learning, allowing learners and teachers to ask and answer questions in real time, enhancing their social interactions.

Although beneficial, distance education has encountered many barriers. For example, Muilenburg and Berge [12] identified and categorized the barriers into 10 clusters, including technical expertise, administrative structure, evaluation/effectiveness, organizational change, social interaction and quality, student support services, threatened by technology, access, faulty compensation and time, and legal issues. Using the 10 clusters of barriers as the categorizing framework, Cho and Berge [1] studied 32 cases of leading organizations in distance education. Their study has shown technical expertise as the dominant cluster of barriers in distance education. Technical expertise consists of technology

infrastructure and technical support, both closely linked to other barriers like user access, student support, and quality of learning. From the viewpoint of learners, Safford and Stinton [13] examined online adult learners' difficulties and perceptions of distance education. Their study found that students were not very exposed to ICT: the online students have shown underdeveloped skills for locating, storing, and retrieving information digitally.

To overcome barriers in distance education, prior research offered useful recommendations on changing organizational structure or improving organizational norms and effectiveness. However, prior research focused on the perspective of the organizations, not on the viewpoint of the learners in distance education. The experiences of online learners and their skills in using the technologies in online learning environments are also a key element in improving the success of distance education. As Wonacott [14] emphasized, ICT in distance education must consider different circumstances of students. Similarly, Kim et al. [15] highlighted that students' apprehension about using ICT and "fast-changing tech" are the most significant issues to addressing distance education (p. 14). Safford and Stinton [13] suggested that, for online course design, it is a good practice to provide opportunities for students to become familiar with online tools at the beginning of a course, followed by later requirements to use these tools to gain skills and knowledge.

In summary, prior studies have suggested the importance of ICT resources and digital skills for achieving student success in distance education. However, it is not clear if online students from underserved communities are equitably equipped in educational technology and digital skills as their peers. Next we draw upon digital divide and digital inclusion studies for further insights.

2.2. Digital Divide and Digital Inclusion

Studies on digital divide started in the mid 1990s and focused on the adoption and use of the Internet technology in the 1990s and early 2000s. According to the U.S. National Telecommunications and Information Administration [16], digital divide referred to "the divide between those with access to new technologies and those without" (xiii). According to this conceptualization, digital divide reflects socioeconomic inequality defined by having access to computers and Internet or not. Starting in the 2000s, researchers have pivoted to the abilities and skills needed for users, different usages of the Internet, and the complexity of access. They argued that digital divide cannot be simply measured by having physical access to computers and the Internet or not; rather, it should be measured by how digital media is used in people's daily life [17].

Although there is no unified definition of digital divide [8,18,19,20], the conceptualizations of digital divide generally specify four areas of importance including attitudes, access, skills and types of usage. While physical access gap has diminished, skills and usage gaps still exist. One factor that appears to be important is the differential possession of digital skills [17]: digital skills are partly about managing the technology and different skills related to content and activities [18].

Researchers found that gender is a crucial predictor of types of Internet use. For example, Jackson et al. [19] found that students used the Internet equally, but they used it for different purposes: male college students tend to use the Internet more for entertainment, while their female counterparts use it for communication and educational purposes. Similarly, Jones et al [20] showed that female college students use the Internet more for communicative and academic purposes compared to the male students. The authors added that those results are not surprising: males spend more time on leisure activities with greater frequency than females, including listening to and downloading music as well as watching and downloading videos. However, these studies focused on the Internet technology in daily life. Our knowledge about student's use of academic technologies for education remains limited. As suggested by Jones et al [20], the attitude of Internet use for education can be a valuable topic for future research.

Compared to digital divide, digital inclusion is a broader concept that concerns individuals' ability to access and use ICT to improve the work and life of the disadvantaged population. According to Sen [7], digital inclusion can be interpreted as the utilization of social computing capabilities by people to participate in society via valuable activities. Similarly, Notley [6] suggests that access to and proficiency in such information and communication technologies are critical for high risk and underserved populations to improve their lives and life chances. Without such technologies, individuals and communities could be hindered and impacted negatively. The pivotal role of digital technology has been further demonstrated in a report published by the Rand Corporation, as it states: "*The digital world is increasingly penetrating the education and skills domain, with technology gradually being used to deliver education, knowledge and skills in new and innovative ways*" [21, p. 2].

In light of the widespread impact of COVID-19 that forced classes to be moved online, students' proficiency in educational technologies and distance learning modality has become essential to their performance in course activities and maintaining social connections with classmates and friends in the online learning environments. Therefore, this study intends to provide an in-depth analysis of the digital barriers that were experienced by an ethnically and economically diverse population of college students.

3. Method: Qualitative Study

We conducted a case study to understand how college students adapted to online learning modality during COVID-19 in spring 2020. We followed the qualitative research method proposed by Miles and Huberman (1996) to perform the data analysis.

The data reported in this study is part of a large project examining educational resilience and learning barriers (not only digital barrier) in a four-year urban, public university in the United States. The university is known for serving an economically and ethnically diverse student population, including 60% of students being Hispanic or Latino, 15% Black or African American, 11% White, 11% Asian, and 3% others. In addition, about half of the enrolling students are first generation, and approximately 60% are Federal Pell grant eligible. Given the diversity of the student background, this university is an ideal research site for us to study student online learning experience and digital barriers during the COVID-19 pandemic.

Three modalities of classes are normally offered by this university: in-person (on-campus), online, and hybrid. In-person classes enroll the majority of students across campus. The learning platform "Blackboard" was utilized and supported as the main web-based course management system. Due to COVID-19, the university suspended all on-campus classes in March 2020 and started "alternative instruction" (online, distance learning), which remained effective for the remainder of the 2020 spring semester.

The survey data was collected via SurveyMonkey in late March to early April of 2020. The survey included open-ended questions to ask about students' views surrounding technology readiness, problems associated with the online learning environments, concerns with COVID-19, learning needs, and demographic background. Examples of the survey questions are: "How concerned are you about the coronavirus (COVID-19) spread in the U.S. now?" "What are the major barriers for you to continue the college classes via the alternative instruction mode (i.e., online, distance

learning) during the remaining weeks of the semester, and how are handling the barriers?" A total of 206 students completed the survey, resulting in a response rate of 45.8% (out of 450 students). It is a convenience data sample collected from the School of Business at the research site.

Among the 206 respondents, 52.4% are female, 66.5% are full-time or part-time employed, and 61.7% reported themselves as FGCS. About 83% of respondents are from upper classes (juniors and seniors) and 7% are graduate students. Table 1 summarizes the distribution of the study participants by their demographic background (i.e., gender, employment status, household income, and ethnic background).

Table 1. Demographic characteristics of the study participants (n=206)		
	Frequency	Percentage
Gender		
Female	108	52.4%
Male	98	47.6%
Employment Status		
Not employed (Full-time Student Only)	69	33.5%
Employed full-time	79	38.3%
Employed part-time	58	28.2%
Household Income		
Less than $20,000	44	21.4%
$20,000 to $34,999	42	20.4%
$35,000 to $49,999	37	18.0%
$50,000 to $74,999	36	17.5%
$75,000 to $99,999	24	11.7%
$100,000 to $149,999	14	6.8%
$150,000 or More	9	4.4%
Ethnicity		
Hispanic or Latino	123	59.7%
Asian or Pacific Islander	31	15.0%
Black or African American	24	11.7%
White / Caucasian	19	9.2%
Others	9	4.4%
First-Generation College Student (FGCS)		
FGCS	127	61.7%
Non-FGCS	79	38.3%
Grand Total	**206**	**100.0%**

As shown in the table, majority of the respondents (59.8%) come from families with household income less than $50,000. Moreover,

ethnic minority students accounted for 86.4% of the sample, including 59.7% Hispanic/Latino, 15% Asian or Pacific Islander, and 11.7% Black or African Americans.

Our coding of the barriers was informed by prior research [22, 23, 24]. New barriers also emerged from our data. Two coders first developed the coding scheme and then coded a subset of the data sample together to discuss and refine the coding scheme. Together, the two researchers coded almost half of the sample, compared and discussed coding, and refined and finalized the coding scheme. Then, one coder followed the agreed coding scheme to complete coding of the remaining data. The inter-rater reliability of coding is satisfactory, with a Cohen's Kappa Index of 0.886, suggesting a high level of agreement between the two coders [25].

The coding result reveals that 31.6% of the respondents reported experiencing digital barriers when migrating to online platforms for all classes in the middle of the 2020 spring semester. The distribution of study participants by digital barrier experience is summarized in Table 2.

Table 2. Distribution of participants reporting digital barriers (n=206)			
	YES-Digital Barrier	NO-Digital Barrier	Total
Gender			
Female	33.3%	66.7%	100%
Male	29.6%	70.4%	100%
Employment Status			
Not employed (Full-time Student Only)	30.4%	69.6%	100%
Employed full-time	30.4%	69.6%	100%
Employed part-time	34.5%	65.5%	100%
Household Income			
Less than $20,000	31.8%	68.2%	100%
$20k - $34,999	42.9%	57.1%	100%
$35k - $49,999	45.9%	54.1%	100%
$50k - $74,999	13.9%	86.1%	100%
$75k - $99,999	25.0%	75.0%	100%
$100k -$149,999	21.4%	78.6%	100%
$150,000 or More	22.2%	77.8%	100%
Ethnicity			
Asian or Pacific Islander	41.9%	58.1%	100%
Black or African American	25.0%	75.0%	100%
Hispanic or Latino	29.3%	70.7%	100%
White / Caucasian	47.4%	52.6%	100%
Others	11.1%	88.9%	100%
First-Generation College Student (FGCS)			
FGCS	28.3%	71.7%	100%
Non-FGCS	36.7%	63.3%	100%
Grand Total	**31.6%**	**68.4%**	**100%**

In the next section, we present the five major types of digital barriers in detail and describe some patterns associated with these barriers by the respondents' demographic and socioeconomic factors.

4. Results

In distance education, the technology aspect relates to the availability of technical devices, tools, and techniques required to transport inputs into outputs. Our data analysis revealed a number of technical issues that emerged due to the sudden shutdown of the university facilities and the transfer of all educational instruction to distance education. The common digital barriers reported by the study participants include slow Internet speed, technical problems, lack of computer resources, lack of Internet access, and skill deficiency. The distribution of the five digital barriers is shown in Figure 1.

Figure 1. Distribution of digital darriers in online learning (n=65)
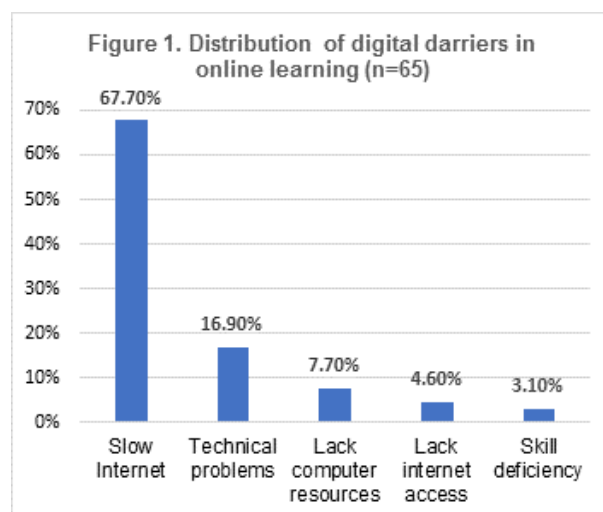
4.1 Digital Barrier: Slow Internet

Slow Internet was the most frequently reported barrier by the survey respondents when it came to

facilitating their distance learning during the COVID-19 pandemic. It refers to the reduced Internet speed due to multiple uses at the same time in a household. This barrier accounts for 67.7% of the reported digital barriers. This is not surprising as all family members were confined to their homes and needed the Internet access to perform their jobs or take online classes, all of which slowed down the Internet speed. As a result of the poor Internet connection, students' learning experience and class performance suffered from unexpected consequences. This is reflected in the following remark:

The biggest barrier is slow Internet, I live with 7 other people and since everyone is home at the same time everyone uses their devices at the same time and it conflicts with my learning.

As shown above, the slow Internet speed at home affected students' academic work, such as completing homework assignments. Meanwhile, during the COVID-19 lockdown, the nomadic study places such as the university library or coffee stores are closed, taking away students' last option for free, fast Internet access. Students in our study have come up with different coping strategies. For some students, to ensure adequate Internet access for conducting online classes, family members had to allocate time slots for each member to access the Internet. One respondent mentioned, "*I ask my family to turn off all devices to allow Wi-Fi to speed up.*" Other students became proactive by anticipating the Internet connection problems and completing online assignments earlier, as one explained, "*I try not to complete tasks last minute in case blackboard is down or my internet is not working.*"

4.2 Digital Barrier: Technical problems

The second frequently reported barrier is technical problems, accounting for 16.9% of the total digital barriers. Technical problems are associated with computer software, hardware, or network during online instructions [23]. Students reported "*Zoom glitches*" or problems with video or audios. Sometimes, causes to a technical problem were not clear, as one student explained below:

My computer sometimes exits out on me randomly. This has happened while taking exams or doing assignments.

During the campus shutdown, the university IT Support Desk remained open, available via phone or email. When students needed technical support with their distance learning, such as Blackboard support or Zoom training, they can call the campus IT Helpdesk during the office hours (9 am—5 pm) or submit a troubleshooting ticket online anytime. However, given the variety of online class schedules and assignment submissions, students who take evening classes or work on assignments during the weekend could not reach the IT Helpdesk when technical problems occurred. Here is an example of technical issues that a student experienced:

One major barrier is relying on my computer and hope that it doesn't crash or that they system doesn't stop working while I am doing work.

4.3 Digital Barrier: Lack of Computer Resources

The third barrier is lack of sufficient computer resources (computer hardware, software, other equipment) to take online classes at home. This barrier accounted for 7.7% of the digital barriers. Insufficient computer resources are hindering students from effectively engaging in the online learning. One such limitation is the incompatibility between outdated computer hardware at home and the latest software program. Without access to computer labs and resources on campus, many students found themselves inadequately equipped at home to participate in online learning in an effective manner. This barrier is reflected in the following remark:

Although my kids are at home, they also have to do homework on the Internet and we take turns doing homework. One computer is not enough. I just we have faster internet and another desktop or a laptop.

For some respondents, they missed the computer equipment needed for a typical home office, such as a printer. Printing services were often provided at facilities on campus. Without the computing equipment, students found themselves losing an important learning aid, as a student explained:

I typically enjoy printing assignments and referring to them and without a printer it is more difficult to manage assignments.

4.4 Digital Barrier: Lack of Internet Access

A small percentage (4.6%) of survey participants reported lack of Internet access. This learning barrier resulted from cost and has been evidenced in U.S. households from over a decade ago [22, 23]. However, this barrier remained during the COVID-19 pandemic in 2020, due to two reasons. First, some students had relied on smartphones for their computing needs at home but found themselves inadequate in accessing the Internet on their phone to take online classes. This is explained below:

I worry about my internet access lasting during this time period because I do not have internet at home and instead use a mobile hotspot to work on homework and work materials.

Another cause to the lack of Internet access is families' worsening financial situation. When family members lost jobs during the COVID-19 pandemic, students could not afford to pay for their Internet access. With limited financial resources, they would first secure their shelter and food, before considering Internet plans. A student expressed this worry below:

Another problem is not being sure I'll have access to the internet for the rest of the semester since family is not working at the moment.

4.5 Digital Barrier: Skill Deficiency

The last digital barrier is skill deficiency, i.e., insufficient knowledge or skills in using online learning platforms such as Blackboard and Zoom [24]. Only a small percentage (3.1%) of respondents expressed their barrier of lacking knowledge and skills in using online technologies like Zoom and Blackboard. Yet, it's worth pointing out that many respondents are holding full-time jobs, so they are managing both employment and academic work simultaneously in the difficult time of COVID-19. This barrier is reflected in the remark below:

I work at a McDonald's and I am a swing manager. It is very challenging having all classes online. I have other responsibilities to worry about also I am not fully known to Zoom so it is hard for me to understand how it works.

4.6 Differences in Digital Barriers by Demographic and Socioeconomic Background

Table 4 summarizes the distribution of the five types of digital barriers by demographic and socioeconomic background of the study participants. As shown in the table, the five types of digital barriers are not evenly distributed across the respondents of different demographic background. One major uneven distribution is that three quarters (75.4%) of the digital barriers were reported by students with household income less than $50,000. We consider these students as low-income students in this study because their household income is below the median household income level in the region where the university is located.

The problem of slow Internet is more prevalent among low-income students and minority students than their counterparts. To work around this problem, some students reported that they "*instead use a mobile hotspot to work on homework and work*

materials." This is consistent with the findings of a Pew Research Center's study, which stated that income is an important factor restricting broadband adoption and use at home; low-income families tend to be more smartphone-dependent and they lack access to multiple internet-enabled devices (e.g., tablets, PCs or laptops) to get online [9].

Table 4. Distribution of the five types of digital barriers (n=65)					
	Slow Internet	Technical problems	Lack computer resources	Lack internet access	Skill deficiency
All	67.7%	16.9%	7.7%	4.6%	3.1%
Gender (0=Female; 1=Male)					
0	33.8%	7.7%	7.7%	3.1%	3.1%
1	33.8%	9.2%	0.0%	1.5%	0.0%
Employment Status (0=unemployed; 1=full-time; 2=part-time)					
0	21.5%	9.2%	1.5%	0.0%	0.0%
1	26.2%	3.1%	3.1%	1.5%	3.1%
2	20.0%	4.6%	3.1%	3.1%	0.0%
Household Income 0="<$20k", 1=<=<35k", 2="<50k",3="<75k", 4="<100k", 5="<150k", 6>=150k					
0	13.8%	4.6%	3.1%	0.0%	0.0%
1	18.5%	6.2%	1.5%	1.5%	0.0%
2	21.5%	1.5%	0.0%	1.5%	1.5%
3	4.6%	1.5%	1.5%	0.0%	0.0%
4	4.6%	1.5%	1.5%	1.5%	0.0%
5	1.5%	1.5%	0.0%	0.0%	1.5%
6	3.1%	0.0%	0.0%	0.0%	0.0%
Ethnicity (1=Asian; 2=African American; 3=Hispanic; 4=White;5=others					
1	16.9%	1.5%	1.5%	0.0%	0.0%
2	3.1%	3.1%	3.1%	0.0%	0.0%
3	38.5%	7.7%	3.1%	4.6%	1.5%
4	7.7%	4.6%	0.0%	0.0%	1.5%
5	1.5%	0.0%	0.0%	0.0%	0.0%
First-Generation College Student					
YES	33.8%	9.2%	7.7%	3.1%	1.5%
NO	33.8%	7.7%	0.0%	1.5%	1.5%

In terms of lacking computer resources, only females, minority students, and FGCS reported such barrier. That is, no male students, no White students, and no continuing-generation students (non-FGCS) reported such barrier. These findings are mostly consistent with previous studies that female and underrepresented students are at a disadvantage in ICT access and usage [i.e., 8, 9].

Technical problems and lack of Internet access seem to be challenges for all students regardless of their demographic and socioeconomic background. This can be partly explained by the high percentage of underserved students who are from low-income families and have minority ethnic background. As Van Dijk [26] has suggested, unequal distribution of resources leads to inequality of digital technological access, which in turn can lead to unequal participation in society that widens inequalities and distribution of resources.

In summary, the study finds that household income, ethnicity, gender and FGCS status of students have different impacts on their digital barriers in distance education.

5. Discussion

COVID-19 has diminished some of the benefits of distance education, such as the flexibility of taking online classes anywhere and anytime. Under the COVID-19 crisis, students were confined in their homes, experiencing slow network and inadequate computing resources required for distance education. Meanwhile, in addition to their academic work, many students struggled with multiple roles, managing demands from their employment (i.e. as essential workers), their family responsibilities of childcare, homeschooling their children, or elderly care. COVID-19 has brought unprecedented digital challenges to the underserved minority groups of college students, hindering their academic success on the online platforms.

However, the participants in our study have demonstrated their resilience in overcoming some of the digital barriers by adopting different coping mechanisms. The two remarks from our study participants below provide two workaround solutions to overcome these challenges:

[Coping for slow Internet]: *There are 3 students in my home so our internet tends to be really slow while we are all doing our homework. I am trying to handle that barrier by having an assigned time we each get to work on our most important assignments in which we need faster internet and try to stay off the internet while the other one works on homework.*

[Coping for lack of Internet access]*: I don't have internet connection at home so I have to be using my mobile hotspot to connect with my computer.*

Although the students from low-income households without sufficient Internet access had attempted to find workaround solutions, they were disadvantaged in their academic progress, compared to their peers from higher-income households. This phenomenon is referred to as the "*homework gap*": low-income students who lack online access lag behind their higher-income counterparts when completing assignments and other school-related activities [4]. The homework gap was widened during the pandemic when all students took online classes, because those students from low-income families could not use school libraries or public WiFi for Internet access as they used to do prior to COVID-19.

Our study showed that household income, gender, ethnicity, and FGCS status of students have different impacts on their digital barriers in distance education. However, the differential use of the computer technologies (network, hardware, software) based on the students' minority background is more complex. This is consistent with prior research, which has suggested that Hispanic, Black, and White students agree that the Internet has a positive effect on their academic lives, but Hispanic students significantly use the Internet less for academic purposes compared to White and Black students [20].

Our study has contributed to the research on digital divide by examining and uncovering the nuances of digital barriers in online learning environments. As van Dijk [17] indicated, digital divide research suffers from a lack of theory: while recent digital divide research relied on causal model building and structural equation modeling, explicit theories are not developed. By revealing the nuances of technical barriers and underlying causes—economical or technological—our study suggests that capital theory [27, 28] could be a useful lens for further investigating the digital divide and digital inclusion phenomenon on the online learning platform. According to Bourdieu [27, 28], capital can present itself in five fundamental forms: economic, cultural, social, symbolic and technical. Economic capital refers to monetary resources (money or property); cultural capital includes shared cultural signals such as attitudes, preferences, and behaviors, as well as educational qualifications; social capital is comprised of social obligations or connections; symbolic capital refers to an individual's accumulated wealth in a symbolic form, such as authority, knowledge, prestige, reputation, or academic degrees; and technical capital captures the

technology-related skills that a person develops using computing equipment. Each form of capital is essential to economic growth of our society.

6. Implications

Students' digital inclusion can help mitigate the economic disadvantages and lack of parental support for working-class students. This initiative is especially important for promoting the digital competence of students from diverse social, economic, and ethical backgrounds. Characteristics of diversity include age, race/ethnicity, gender, socioeconomic status, sexual orientation, physical abilities, religious or political beliefs, skills, experience, etc., which are all combined to create unique individuals. Prior study also stresses the importance of learners' social context and suggests that the sense of isolation may engender online learning [29]. In higher education, diversity in student populations has increased as opportunities for underrepresented groups to attend institutions of higher education have grown [30]. However, as our study has shown, to prepare the students for the technological advances in academic and professional settings, educational institutions need to design and implement programs to overcome the digital barriers and to enhance students' digital inclusion in the online learning environment.

Research on equity-minded practices in higher education [31] has suggested a framework for promoting the practices of remote teaching. The framework includes five key principles: (1) Be intrusive: "be proactive; we faculty don't wait for students to fall through the cracks." (2) Be relational: "build authentic relationships between students and faculty that are grounded in trust" (3) Be culturally relevant and affirming: "make the course culturally relevant, by connecting course content to our everyday life." (4) Be community focused: "to build a sense of community belonging and agree upon community norms." (5) Be race conscious: "be intentional about providing students with opportunities to engage racial and equity issues within the context of the course."

To help online students resolve technical problems and engage them in the online learning, our study suggests the following equity-minded practices:

Recommendation #1: To address the barriers of slow Internet or no Internet access, higher educational institutions should mobilize school resources and provide mobile Internet services to students, especially low-income students. In addition, support by and involvement of private and public sectors are important to remedy these digital barriers in distance education. In the short term, private

sectors have started to make efforts in response to COVID-19. For example, Internet service providers such as Verizon voluntarily pledged to limit fees, forgive fines, and remove data caps in the spring of 2020 [3]. However, to achieve and sustain academic continuity in distance education for the long term, government's involvement is needed. To raise awareness of the enormity and immediacy of the digital divide, the No One Left Offline (NOLO) in San Francisco, an all-volunteer nonprofit, calls for involvement of government to achieve digital inclusion [3].

Recommendation #2: To address the technical problems experienced by students during distance learning and lack of computer resources or skills, higher educational institutions should consider (1) implementing a tech loaner program that provides students, especially low-income, minority, and FGCS with free laptop computers and updated software that are sufficient for their online learning needs during the semesters; (2) providing self-paced training on online learning platforms (e.g., Zoom and Blackboard) to students, especially those with full-time jobs, to accommodate their work schedule; (3) extending the office hours of IT Help Desk to accommodate evening and weekend classes; and (4) reducing response time of the IT Help Desk by hiring more qualified technicians for support so that student's tech problems could be solved quickly to minimize the interruptions to their distance learning.

Recommendation #3: To improve community focus and diversity awareness, educational institutions should (1) agree upon communication norms between instructors and students for online classes (i.e., such as expected time to return an email); (2) set up the expectation and communication norms for team collaboration; (3) create assignments that are related to the current health and economic crisis; and (4) create discussion forums on understanding how the COVID-19 crisis affects communities of color disproportionally.

7. Conclusion

We would like to acknowledge the limitations of the study. First, the study used a convenience sample, not a random selection, which could affect the generalizability of the findings. Second, the survey was conducted during the first two weeks of transition to distance learning. As student learning experience could have changed after this specific window of time, it would be helpful for future research to employ more advanced sampling strategies and conduct a longitudinal study to

measure student performance in the face of digital barriers arising from distance education.

Although inequalities within society have always existed, distance education in the times of crisis created an even stronger division. Our study further suggested the demographics and socioeconomic status are important factors in influencing learners' technology access, use, and proficiency in the online learning environment. To some extent, COVID-19 has expanded the digital divide in distance education [3, 4]. Educational institutions and policymakers should consider designing and implementing intervention programs focusing on improving resource access and developing the digital skills essential for students from underserved communities to achieve their academic goals during COVID-19 and beyond.

8. References

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