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Xuefei "Nancy" Deng and Sherine El Hag

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Digital Inequality and Two Levels of the Digital Divide in Online Learning: A Mixed Methods Study of Underserved College Students

Xuefei "Nancy" Deng
Sherine El Hag
College of Business Administration & Public Policy
California State University Dominguez Hills
Carson, CA 90747, USA
ndeng@csudh.edu, selhag@csudh.edu

ABSTRACT

The rapid surge in the use of academic technologies and online learning platforms prompted by the COVID-19 pandemic illuminated the digital disparities between underserved college students and their more privileged counterparts. While previous research underscores the significance of technology access and digital proficiency in online education, our understanding of the digital divide in online learning remains limited. To address this deficiency, this study employs a mixed-methods approach—combining qualitative and quantitative analyses—to investigate the manifestation of the digital divide and digital barriers among underserved college students during the pandemic. We collected data from 220 students from a minority-serving four-year public university in the United States. Our qualitative analysis reveals distinct first- and second-level digital divides in online learning. However, the quantitative analysis fails to identify significant associations between digital barriers and demographic variables such as first-generation status and household income. Through supplementary thematic analysis, two crucial themes emerge illustrating the technological disadvantages encountered by underserved college students. This study contributes to both information systems research and educational practices by offering a nuanced exploration of the digital divide and digital inequality in online education and by providing actionable recommendations aimed at fostering digital equity among underserved college students.

Keywords: Online education, Information technology, Digital divide, Digital equity, Underserved students, COVID-19

1. INTRODUCTION

Over the past two decades, efforts have been made to narrow the gap in Internet and computer access between underserved college students (e.g., students of color, first-generation college students) and their more privileged counterparts. However, a disparity persists in their use of information communication and technology (ICT). This enduring gap, referred to as the digital divide, presents a significant obstacle in the current context of technology-mediated learning (TML), where online learning platforms facilitate course delivery, student-teacher interactions, and learning tasks (Alavi & Leidner, 2001). In college courses reliant on ICT for instruction and communication, the digital divide results in unequal participation among students (Iyer & Chapman, 2021; Welser et al., 2019).

Disparities in ICT access and usage have long been present in our society. However, the sudden shift to fully online course delivery during the COVID-19 pandemic highlighted the profound impact of this division (Frazier, 2020; Lee, 2020). With the closure of campuses and the transition to online learning worldwide, over 1.2 billion students across 186 countries were affected (Li & Lalani, 2020). Underserved students, due to their technological disadvantages, struggled to fully engage in online learning activities, placing them at a disadvantage compared to their peers (Iyer & Chapman, 2021).

For the purposes of this study, we define underserved students in accordance with the criteria specified in the ACT Report (2014), which include individuals from ethnic minority backgrounds, low-income households, or those who are first-generation college students. Given the socio-economic challenges and first-generation status of these students, scholars and practitioners alike have called for further research to understand these technological disparities and develop solutions to address them (e.g., Iyer & Chapman, 2021; Welser et al., 2019).

Previous research has underscored the critical role of technological resources and digital skills in facilitating online learning. However, our understanding of the digital divide and digital inequity in online education remains limited. A recent editorial publication has urged a reexamination and deeper investigation into the phenomenon of the digital divide, particularly in light of the rapidly evolving landscape of online education (Deng, 2023). Underserved college students represent a vulnerable population within the U.S. higher education system, and they have been disproportionately affected by the challenges posed by the COVID-19 pandemic (Lee, 2020). This study addresses the following three questions:

1. *How is the digital divide characterized in online learning?*
2. *Do underserved students and their counterparts experience digital barriers differently in online learning?*
3. *What technological disadvantages do underserved students face in online learning?*

The study employs a mixed methods approach, incorporating both qualitative and quantitative analyses, and a minority-serving U.S. university as its research site. Drawing upon existing research on e-learning, the digital divide, and digital inequity, our qualitative data analysis reveals digital barriers associated with two levels of the digital divide. Our quantitative data analysis examined the relationships between these digital barriers and demographic and socio-economic factors, such as generational status, household income, and employment status. Additionally, we conducted a thematic analysis of student narratives to uncover dimensions of technological disadvantages and the underlying causes of the two levels of the digital divide in online learning.

The remainder of the paper is structured as follows: Section 2 provides a review of the literature on e-learning, the digital divide, and digital inequality. Section 3 outlines the mixed methods employed. Sections 4 and 5 present the results of qualitative and quantitative data analyses, respectively. Section 6 presents the supplemental thematic analysis and results, and Section 7 discusses the study findings, theoretical contribution, and practical implications. The paper concludes in Section 8 with limitations and future research directions.

2. THEORETICAL BACKGROUND

2.1 Online Learning and Key Success Factors

Online learning, also known as technology-mediated learning, allows learners to engage in educational activities remotely through synchronous or asynchronous instruction and meetings, facilitated by network technologies. This definition aligns with prior research (e.g., Hayashi et al., 2020; Iyer & Chapman, 2021). Technological affordances such as videoconferencing and collaborative workgroups play a crucial role in fostering collaborative tasks (Kirschner et al., 2004). ICT aids students in achieving learning objectives by promoting participation, information exchange, and interaction among learners. In today's educational landscape, college students' access to technology resources and digital skills significantly impact their learning outcomes and academic achievements, particularly in online learning environments (Iyer & Chapman, 2021). However, e-learners may encounter challenges due to insufficient technical expertise, infrastructure, and technical support, resulting in ineffective online interactions and diminished learning quality (Aslan, 2021; Seynhaeve et al., 2022).

Prior research highlights several key factors contributing to success in online learning. First, students' technical skills are crucial, with rapidly evolving technologies and ICT-related anxiety being key areas of concern (Kim et al., 2008). Additionally, Safford and Stinton (2016) noted underdeveloped skills in information location, storage, and retrieval among online adult learners, suggesting the importance of early exposure to online tools to enhance skills. Second, individual learners' behavior within the e-learning environment, including interactions with instructors and peers, plays a significant role. Seynhaeve et al. (2022) identified different interaction types, emphasizing the need for balancing learner-content, learner-teacher, and learner-learner interactions. Finally, educators' understanding of student perceptions is vital for enhancing the quality of online learning experiences. Ellis et al. (2009) found that interactive activities facilitated by teachers, such as moderating online discussions and providing feedback, positively impact student motivation and engagement. As online education evolves, live interactions using video cameras and breakout rooms on platforms like Zoom have become increasingly common (Aslan, 2021).

The global COVID-19 pandemic has exacerbated challenges in online education, particularly for underserved student populations. Deng and Sun (2022) identified various barriers to online learning among underserved students, including technical, cultural, environmental, work/school balance, social, and financial barriers. Moreover, they found that underserved students faced multiple barriers simultaneously, with technical barriers frequently intertwined with other challenges. Iyer and Chapman (2021) highlighted technological disadvantages experienced by students transitioning to synchronous online learning, attributable to technical issues and social factors like dependent care responsibilities and work commitments. These findings underscore the need to explore and address the digital divide and digital inequality in online education.

2.2 Digital Divide: Levels and Causes

The digital divide initially referred to the gap between those with access to new technologies and those without (National Telecommunications and Information Administration, 1999). Initially, it focused on socioeconomic disparities in physical access to computers and the Internet (Gunkel, 2003). Subsequently, researchers introduced the term "second-level digital divide" to describe differences in user skills (Hargittai, 2002), Internet usage behaviors (Bonfadelli, 2002), and access complexity (van Dijk & Hacker, 2003).

To measure the second-level digital divide, researchers have examined three types of digital skills: operational, informational, and strategic (Steyaert, 2002). These skills encompass operational technology use, information handling, and strategic decision-making (van Dijk, 2005). In the context of Web 2.0 and social networking technologies, researchers have expanded these skills to include communication and socio-emotional skills (Ferrari, 2012). Two common terms used by digital divide researchers are "digital competence," defined as a combination of information, communication, content creation, and problem-solving skills (Ferrari, 2012), and "digital skills," referring to operational technology management and various content-related abilities (van Deursen et al., 2014).

In addition to conceptualizing the digital divide, researchers have paid attention to its causes. Researchers have identified individual and socioeconomic factors as common causes of the digital divide. Table 1 presents the four factors—income, education, race/ethnicity, and employment status—that are related to the characteristics of underserved students in our study.

Various factors contribute to the digital divide, including disparities in ICT usage and individual skills. Even among individuals with Internet access, those from disadvantaged

backgrounds often fail to fully engage in online opportunities (Eynon & Helsper, 2011). Ethnicity plays a significant role in predicting Internet usage patterns. For instance, Jones et al. (2009) observed that students from three different racial groups (Hispanic, Black non-Hispanic, and White non-Hispanic students) used the Internet predominantly for social communication, while sharing similar positive attitudes toward its educational benefits. Moreover, differences in ICT skills are influenced by education and employment status. Education remains a critical determinant across all skill levels, as evidenced even in affluent countries like the Netherlands (van Deursen & van Dijk, 2011). Individuals with more education tend to use advanced digital media applications for career advancement and academic pursuits, whereas those with lower education levels often use simpler applications for entertainment and communication purposes (van Dijk, 2017). Similarly, employment status is linked to varying levels of digital skills, with full-time employed individuals and students typically exhibiting the highest proficiency (van Deursen et al., 2014).

Causes	References
Income	Bonfadelli, 2002; Cotten & Jelenewicz, 2006; van Deursen & van Dijk, 2014
Education	van Deursen & van Dijk, 2011; van Dijk, 2017
Race/Ethnicity	Cotten & Jelenewicz, 2006
Employment	Cotten & Jelenewicz, 2006; van Deursen & van Dijk, 2011, 2014; van Deursen et al., 2014

Table 1. Causes of the Digital Divide

Despite advancements in ICT access, disparities in resource access, skills, and usage persist (van Deursen & van Dijk, 2019). Van Dijk (2005) coined the term "deepening divide" to emphasize that digital inequality extends beyond physical access to encompass daily media use. He called for further research into factors influencing the divide, including attitudes toward technology, new media channels, educational views of digital aptitude, and cultural factors (van Dijk, 2006). Drawing on a theoretical framework combining the structuration and acceptance theories, van Dijk (2017) proposed a cycle of resource appropriation leading to unequal participation in society, perpetuating inequalities. Informed by this theory, we investigate unequal technology access and usage in online education.

2.3 Inequality and the Impacts on Online Education

"Digital inequality encompasses the disparities in digital access, skills, usage, and outcomes, which are influenced by individuals' societal positions and subsequently impact their life opportunities" (Hargittai, 2021, p. 1). In the context of social media usage, digital inequality refers to systematic variations in access, skills, and usage patterns among people from diverse socioeconomic backgrounds (Büchi & Hargittai, 2022). Individuals from lower socioeconomic levels often face disadvantages in accessing ICT, including social networking technologies and social media platforms, leading to limited proficiency in utilizing these digital tools.

Much of the research on digital inequality focuses on disparities in access, another word for the digital divide, which has been measured through various metrics. DiMaggio et al. (2004) highlight how disparities in access reinforce inequalities in economic and social opportunities, emphasizing that understanding digital inequality requires examining the impact of technology and information on social disparities. They argue that unequal access to and usage of information contributes to social inequality and perpetuates patterns of disadvantage (DiMaggio et al., 2004).

With universities increasingly transitioning to online program offerings, technology access and network connectivity have become essential for accessing higher education (Murphy et al., 2014). Previous studies have demonstrated that digital inequalities adversely affect student achievement (Gonzales et al., 2020; Willems et al., 2019). Consequently, both educational institutions and academia stress the importance of promoting digital equity among underserved students in higher education (e.g., Puigjaner, 2016). The National Digital Inclusion Alliance (2019) defines digital equity as "a condition in which all individuals and communities have the information technology capacity needed for full participation in our society, democracy, and economy." Similarly, in the context of online education, we define digital equity as ensuring that all students have equal ICT capacity and opportunities to fully participate and engage in the online learning environment enabled by the Internet and digital technologies.

3. METHOD: MIXED METHODS

This study adopts mixed methods (qualitative and quantitative) to examine whether, and if so how, the digital divide and digital inequality were manifested in online learning and experienced by underserved college students at the beginning of the COVID-19 pandemic. Qualitative and quantitative analyses complement each other and potentially provide a richer exploration of the linkages across variables (Mingers, 2001). For the qualitative data analysis, we followed the research method proposed by Miles and Huberman (1994). With the quantitative data analysis, we performed chi-square analysis.

3.1 Research Site and Data Collection

The research site is a minority-serving four-year public university located on the west coast of the United States. It serves an economically and ethnically diverse student population, with 60% of students being Hispanic or Latino, 15% Black or African American, 11% White, 11% Asian, and 3% other. In addition, 54% of its student body are first generation college students, and 64% are eligible to apply for the U.S. Federal Pell Grants, usually awarded only to undergraduate students who display exceptional financial need. The research site and its student population represent the underserved students. According to the ACT Report (2014), an underserved student (1) is a member of a minority (i.e., race/ethnicity is African American, American Indian/Alaska Native, Hispanic/Latino, or Native Hawaiian/other Pacific Islander); (2) has a low income (combined parental annual income is less than or equal to $36,000); or (3) is the first generation in college (the highest parental education level is a high school diploma or less).

Prior to COVID-19, the university offered in-person classes, in which most of the students were enrolled. To contain the coronavirus outbreak in the United States, the university closed the campus in mid-March of 2020 and moved all in-

person classes to online classes in late March. The university adopted the learning platform Blackboard as its main web-based course management system and required instructors to use the Zoom videoconference tool for synchronous instruction. Because of the diverse socioeconomic backgrounds of its student population, we believe this research site is appropriate for us to examine students' digital barriers and the digital divide in online learning at the beginning of the COVID-19 pandemic.

Data were collected during a two-week period from late March to early April of 2020 through an online questionnaire, which included open-ended questions about students' experiences during the first week of transitioning from in-person instruction to online classes, their concerns about COVID-19, and the types of support they would request from the university. Students were also asked to rate their proficiency with the content management system Blackboard and the Internet video and audio call services of Zoom. The questionnaire also included demographic questions such as ethnicity, employment status, and annual household income. On average, each survey took 15 minutes to complete. We collected a total of 220 completed surveys (from 450 students), resulting in a response rate of 48.9%. Among the 220 respondents, 62.7% of them were first-generation college students (FGS) and 82.3% of them were undergraduate students from the upper-level classes (juniors and seniors). Other sample characteristics include female (51.8%), employed full time (39.5%), and employed part time (28.6%).

Minority ethnic students accounted for 85% of the data in our sample: 59.5% Hispanic/Latino, 15.5% Asian and Pacific Islander, and 10.9% Black or African American. The remaining are: 9.5% White/Caucasian and 4.5% other. Our data sample is representative of the university student population, especially in relation to the percentage of Hispanic/Latino students (59.5% in our sample vs. 60% at the university) and the percentage of FGS (62.7% vs. 54%). Moreover, 40.5% of the respondents come from low-income families, with self-reported annual household income less than $35,000. We adopted $35,000 to categorize the two income groups, similar to the criterion (less than $36,000) defined as low income in the ACT Report (2014). The distribution of the other income categories is 17.7% ($35,000 to $49,999), 19.5% ($50,000 to $74,999), 11.4% ($75,000 to $99,999), and 11.4% ($100,000 or more).

3.2 Data Coding and Analysis

Our coding of digital barriers was informed by prior research (Galusha, 1998; Muilenburg & Berge, 2005; Ng, 2012). New barriers also emerged from our data. We first developed the coding scheme, and then coded 66 (30%) of the 220 responses together to discuss and refine the coding scheme. Table 2 summarizes our coding scheme and definitions, with coding examples.

Using the refined coding scheme, we completed the coding of the remaining data, compared our coding results, and resolved the differences in our coding to reach agreement. The coder inter-rater reliability is satisfactory, with a Cohen's Kappa Index of 0.863, suggesting a high level of agreement (Ryan & Bernard, 2000).

4. RESULTS OF QUALITATIVE DATA ANALYSIS

ICT is essential for online learners to complete academic activities and achieve learning objectives. Our qualitative data analysis reveals a gap in students' access to the Internet and computer resources, as well as gaps in their digital skills and technology use. Our study participants reported four types of digital barriers at two levels, which are presented next.

Digital Divide Construct	Digital Barrier & Definition	Example
First-level Digital Divide		
Internet Access	*Internet access problem:* Reduced Internet speed due to simultaneous, multiple users in the household *(Identified from the study)* Cost and access to the Internet (Galusha, 1998; Muilenburg & Berge, 2005)	"The barrier is having to battle with lackluster Internet speed on a regular basis."
Computer Resources	*Lack of computer resources:* Insufficient computer resources (computer hardware, software, other equipment) to take online classes at home *(*Galusha, 1998; Muilenburg & Berge, 2005)	"I have a laptop; unfortunately, it is old and unable to download the recent programs required for my assignments."
Second-Level Digital Divide		
ICT Use	*Technical problems:* Problems resulting from using the computer software, hardware, or network to conduct online learning tasks (Modified from Muilenburg & Berge, 2005*)*	"The major issue I have is the computer glitches during the online class."
ICT Skills	*Skill deficiency:* Insufficient knowledge or skills to use technologies for the online learning platform, such as Blackboard, Zoom (Modified from Ng, 2012*)*	"My challenge is understanding how certain computer programs work."

Table 2. Coding Scheme and Coding Example

4.1 First-Level Digital Divide: Access to ICT

The respondents' reporting of the digital barriers in Internet access and computer ownership revealed the first level of the digital divide among the underserved students.

4.1.1 Deficiency in Internet Access. Slow Internet service was the most frequent barrier to online learning reported by the study participants, accounting for 67.7% of the barriers. This finding is not surprising, as many family members who were stuck at home needed to access the Internet to perform their jobs or take online classes, which in turn slowed down the Internet speed. This barrier is reflected in the remark: "For the most part it's bad Internet. For example, sometimes the Internet cuts out or something to look up takes a while to load." The slow Internet speed affected not only their participation in synchronous course instruction and classroom activities but also their online completion of course assignments. Moreover, it could lead to poor results on their timed tests. One respondent explained, "Sometimes I do have slow Internet and get worried that while I am taking a quiz it will shut off."

To resolve these problems, some students tried to find access to a safe study location with fast Wi-Fi. However, during the COVID-19 lockdown, the nomadic study places such as the University library or Starbucks Coffee were closed, making it difficult to overcome the barrier. Different coping strategies were employed: for some students, to ensure adequate Internet access for online classes, family members had to allocate time slots for each member to access the Internet; other students became proactive by anticipating the Internet connection problems and making family arrangements for Internet access. This strategy is reflected in these two remarks: "I ask my family to turn off all devices to allow Wi-Fi to speed up" and "I have tried setting up a schedule to help myself and my two sisters (who are also in college) to have study time and to set up a time frame on who can use the computer during a certain time."

In addition to slow Internet service, a small percentage (4.6%; n=10) of participants reported a lack of Internet access. One respondent noted: "I don't have Internet connection at home so I have to be using my mobile hotspot to connect with my computer." Students who relied on smartphones for their computing needs at home found using a Smartphone data plan inadequate for taking online classes. A few other students expressed worries about losing Internet access simply because their family members lost jobs due to COVID-19 and they were no longer able to afford an Internet connection.

4.1.2 Lack of Computer Resources. Insufficient computer resources hindered students from effectively participating in online classes. Some students reported a lack of computers at home because they had relied on computer resources at the University library and computer labs prior to the pandemic. When asked about the major barriers to their online learning, one female student noted, "My barriers would be I have no computer and there are children in the house." Another limitation was the incompatibility between outdated computer hardware at home and the latest software required for a class. For example, one student explained that his laptop was "old and unable to download the recent programs required for class assignments." Without access to computer labs and resources on campus, many students found themselves inadequately equipped to take online classes from home.

4.2 Second-Level Digital Divide: ICT Use

Additional barriers in the online learning environment emerged. Our study participants reported two additional barriers: technical problems encountered during ICT use and lack of skills in using ICT. Such barriers revealed the second level of the digital divide in online learning.

4.2.1 ICT Use - Technical Problems. During online instruction, students experienced technical problems with the computer software, the hardware, and the network. Technical problems were the second most frequently reported barrier, accounting for 16.9% of the total. Students reported "Zoom glitches" or problems with the video or audio. Sometimes the cause of a technical problem was not clear, as one student recalled, "I remember I had to take a test online, but if you close out the tab, the test will submit itself regardless if you finished or not."

When students needed technical support for their online classes, such as Blackboard support or Zoom training, they could call the campus IT Helpdesk or submit a troubleshooting ticket online. However, given the variety of evening schedules for their online classes and the high call volume during some time periods, students could not always reach the IT Helpdesk on time. Students shared appreciation for the support from their instructors and peers under those circumstances. A student explained, "Sometimes the connection creates a lag in the evening lecture or cuts out [the] audio but the professors have been very accommodating." Another student elaborated on their backup plan when encountering technical problems such as Zoom glitches, "My peers and [I] utilized FaceTime on our iPhones when Zoom was not readily available for everyone."

4.2.2 ICT Use - Skill Deficiency. Only a small percentage of respondents expressed challenges associated with lacking knowledge and skills in using online technologies like Zoom and Blackboard. One student mentioned that the biggest digital barrier was "understanding how certain computer programs work."

In summary, our qualitative analysis has identified two distinct levels of the digital divide prevalent in online learning, attributed to several individual and socioeconomic factors. Specifically, the absence of digital access to requisite technologies may stem from inadequate technical infrastructure, unaffordability of devices, or low levels of digital literacy (Alexander et al., 2019). These results indicate the need to provide students with both adequate technology resources (e.g., hardware, software, network access) and sufficient training for effective use of learning management system (LMS) and online videoconference tools to enable them to participate equally in online learning (both synchronous and asynchronous). Subsequently, we conducted quantitative analysis to ascertain variations in student experiences concerning digital barriers across diverse backgrounds.

5. RESULTS OF QUANTITATIVE DATA ANALYSIS

5.1 Distribution of Digital Barriers Among Underserved Students

Overall, one third (33%) of the 220 respondents reported experiencing a digital barrier. More continuing-education students (those who are not FGSs) reported digital barriers than did FGSs, at 40% and 29% respectively. Continuing-generation

students (CGSs) are not the first college students in their family; they have at least one parent with a Bachelor's or higher degree. In addition, students reported more problems with inadequate Internet access than with technology use, at 25% and 8% respectively. Table 3 summarizes the distribution. The percentages are calculated based on row total.

As shown in Table 3, a higher percentage of White/Caucasians and Asian/Pacific Islanders reported digital barriers, at 52% and 41% respectively, followed by 31% of Hispanic/Latino and 25% of Black/African American students. The presence of digital barriers also varied by household income levels. At least four of ten students with family income between $20,000 and $49,999 reported a digital barrier, compared to two of ten students from families with higher income ($50,000-$74,999).

5.2 Associations Between Digital Barriers and Demographic Factors

We performed chi-square analyses to test the association between the digital barrier (Yes/No) and various demographic and socioeconomic factors, including FGS status, employment status, and household income level. Overall, there was a marginally significant relationship between the digital barrier and FGS status, as shown in the chi-square analysis result of $\chi^2(2, N=220) = 2.94$, $p = .086$. We also tested the association between digital barriers and household income (<35k vs. >=35k), but the association was not significant, as shown in the chi-square test result of χ^2 (2, N = 220) = 1.024, p = .312. These results suggest that FGS status or household income alone may not be a significant factor in college students' experiences of digital barriers. Rather, the interactions between the FGS status and demographic variables, such as ethnicity and annual household income, may be helpful in explaining the differences. We did not test the association between digital barriers and ethnicity because of the sample composition: 70% of the respondents identified as Black/African American or Latinx. Tables 4 and 5 report the distribution of digital barriers by generational status and the two demographic factors (ethnicity background and household income) respectively.

The quantitative analysis did not show significant differences in digital barriers among the students with different demographic and socioeconomic backgrounds. A further analysis, beyond the group level (i.e., FGS), may generate insights into these students' experiences. As proposed by scholars of intersectionality (e.g., Crenshaw, 1989; Trauth et al., 2016), individuals' experiences and behaviors are shaped by the intersection of multiple social categories, such as race/ethnicity and socioeconomic status. To explain the insignificant results from the quantitative analysis, we conducted a supplemental qualitative analysis of student narratives to obtain a nuanced understanding of their technological challenges.

	Barrier-Internet Access	Barrier-Technology Use	No digital barrier	Grand Total
Grand Total	25%	8%	67%	100% (n=220)
Generational Status				
FGS	22%	7%	71%	100% (n=134)
CGS	30%	10%	60%	100% (n=86)
Race/Ethnic Background				
Hispanic or Latino	24%	6%	69%	100% (n=131)
Asian or Pacific Islander	35%	6%	59%	100% (n=34)
Black or African American	13%	13%	75%	100% (n=24)
White / Caucasian	33%	19%	48%	100% (n=21)
Other	10%	10%	80%	100% (n=10)
Household Income				
1-Less than $20,000	21%	11%	68%	100% (n=47)
2-$20,000 to $34,999	31%	12%	57%	100% (n=42)
3-$35,000 to $49,999	41%	5%	54%	100% (n=39)
4-$50,000 to $74,999	14%	5%	81%	100% (n=43)
5-$75,000 to $99,999	16%	16%	68%	100% (n=25)
6-$100,000 or More	24%	0%	76%	100% (n=25)
Employment Status				
Not employed (Students only)	24%	7%	69%	100% (n=70)
Employed full-time	24%	8%	68%	100% (n=87)
Employed part-time	27%	10%	63%	100% (n=63)

Table 3. Digital Barriers by Generational Status, Race/Ethnicity, and Household Income

	Barrier-Internet Access	Barrier-Technology Use	No digital barrier	Grand Total
First-generation students (FGSs)				
Asian or Pacific Islander	28%	0%	72%	100%
Black or African American	0%	23%	77%	100%
Hispanic or Latino	24%	6%	70%	100%
Other	0%	17%	83%	100%
White / Caucasian	40%	0%	60%	100%
Total	22%	7%	71%	100%
Continuing-generation students (CGSs)				
Asian or Pacific Islander	44%	13%	44%	100%
Black or African American	27%	0%	73%	100%
Hispanic or Latino	26%	6%	69%	100%
Other	25%	0%	75%	100%
White / Caucasian	31%	25%	44%	100%
Total	30%	10%	60%	100%

Table 4. Digital Barriers by Student Generational Status and Ethnicity Background

	Barrier-Internet Access	Barrier-Technology Use	No digital barrier	Grand Total
First-Generation Students (FGSs)				
1-Less than $20,000	16%	6%	77%	100%
2-$20,000 to $34,999	32%	12%	56%	100%
3-$35,000 to $49,999	36%	0%	64%	100%
4-$50,000 to $74,999	14%	7%	79%	100%
5-$75,000 to $99,999	8%	15%	77%	100%
6-$100,000 or More	11%	0%	89%	100%
Total	22%	7%	71%	100%
Continuing-Generation Students (CGSs)				
1-Less than $20,000	31%	19%	50%	100%
2-$20,000 to $34,999	25%	13%	63%	100%
3-$35,000 to $49,999	47%	12%	41%	100%
4-$50,000 to $74,999	15%	0%	85%	100%
5-$75,000 to $99,999	25%	17%	58%	100%
6-$100,000 or More	31%	0%	69%	100%

Table 5. Digital Barriers by Student Generational Status and Household Income

6. SUPPLEMENTAL THEMATIC ANALYSIS

We performed a thematic analysis of student responses to the open-ended questions in the survey. Thematic analysis is a qualitative method for identifying, analyzing, organizing, describing, and reporting themes found within a data set (Braun & Clarke, 2006). To analyze the data, we followed a thematic analysis procedure described by Braun and Clarke (2006) and coded the data from the narratives of the survey respondents. We (the two researchers) coded the qualitative data together and our thematic analysis revealed two important themes related to the technological disadvantages of underserved college students, as presented next.

6.1 Contextual Factors During COVID-19 Contributing to Digital Divide in Online Learning

Our analysis suggests that the two levels of digital divide (ICT access and use) were associated with new factors pertaining to the lockdown and quarantine mandated during the pandemic. The barrier of lacking Internet access was due not only to financial reasons (e.g., no money to pay for high-speed Internet) but also to contextual factors such as increasing demand for Internet access by more people in the same household, as reflected in the remark:

- *The big barrier to my learning 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* (FGS; 21-year old; female; employed full-time; junior; Hispanic or Latino; Household income: $20,000 to $34,999; single)

Prior to COVID-19, students did not experience these digital barriers because they used public computing resources, such as university libraries, computer labs, or even public libraries. As one FGS explained:

- *I live in a 1-bedroom apartment with 3 other family members so lack of space is an issue when trying to find a quiet space for Zoom or studying. Internet is a little unstable so sometimes we won't have Internet for 1 day or so. Before COVID 19 I would stay at the school library or my local public Library to study and get homework done. Those spaces also had better Internet*. (FGS; 25 years old; female; employed part-time; junior; Hispanic or Latino; Household income: $35,000 to $49,999; single)

When asked about the support they desired from the university, students expressed needs for technology resources, such as loaning laptops, providing mobile Wi-Fi, and offering more financial resources. In addition, they appreciated professors' flexibility. Two students explained,

- *I would like the university to be more flexible with assignments and exams deadlines and allow students to retake exams if Internet issues may arise.* (FGS; 41 years old; male; employed full-time; senior; Hispanic or Latino; Household income: $35,000 to $49,999; married)
- *Perhaps getting the opportunity to get a second chance on homework or even exams because any technical error can occur while conducting these tasks.* (FGS; 21 years old; male; not-employed (student only); junior; Hispanic or Latino; Household income: $20,000 to $34,999; single)

6.2 Multifaceted Factors Associated With Technological Disadvantage in Online Learning

The technological disadvantage is multifaceted. Other emerging factors include difficulty in accessing online learning due to family responsibilities (taking care of the young or elderly) and employment obligations (working from home and changing work shifts). Family-related challenges were frequently reported. As many students at this minority-serving institution are non-traditional students (e.g., adult students, students with children, or students who are employed full time), they encountered family-related challenges when attempting to adapt to online learning during the pandemic. This challenge is reflected in these two remarks:

- *My barriers are having to stay up longer at night due to taking care of my small children and taking care of house chores. Personal life interferes too much when I am trying to complete online assignments*. (FGS; 34 years old; senior; male; employed full-time; Hispanic or Latino; Income: $50,000 to $74,999; married)
- *In my case, I don't have an impact with slow Internet or study space, the only thing I need to manage is the time with my kids which I'm providing care for and time to do their academic work while I try to complete mine.* (CGS; 32-year-old female; not employed; junior; Hispanic or Latino; household income $100,000; married)

Some students encountered employment-related challenges while trying to complete their academic studies online. As shown below, two students explained their struggle to balance their employment and study:

- *For me, it is my job because of the high number of shifts I have to cover due to the virus and call-offs of work.* (CGS; 27 years old; junior; male; employed full-time; Hispanic or Latino; household income <$20,000; single)
- *I am still required to work, and my hours have increased to 60 hours a week, which has caused a huge amount of stress. The instructors should consider lightening the workload for students.* (FGS; 29 years old; female; senior; employed full-time; Black or African American; Income: $75,000 to $99,999; married)

6.3 Instructional Ambiguity

In addition to the technological barriers, students also reported challenges arising from faculty members' course design and course delivery in the online environment. We refer to this challenge as "instructional ambiguity," e.g., lacking clear instructions or timely communication from faculty members. In this regard, two challenges were frequently reported. First, the students felt that some course designs did not adapt to the online learning mode: the same course design for the in-person delivery mode was mechanically copied and moved to the online LMS. Two students expressed their concerns:

- *I think it is just the lack of instruction from some professors. A lot of students had never done an online class before and don't know how to navigate on video call services… I think they should make our classes pass or no pass. We are in a difficult time. Although we now have more time to focus on our work, we also have more hardships that surfaced*. (FGS; 20 years old; female; employed part-time; junior; ethnicity: Other; Household income: $20,000 to $34,999; single)
- *The major barriers for college classes online are having better communication to the professors and the content they provide as some information is lost within the mode they teach on-screen. Whether it is a small number of questions or in a discussion of certain topics*. (CGS; 20-years old; male; unemployed (student-only); Hispanic or Latino; Income: $20,000 to $34,999; single)

Second, when all courses were moved online, the students were overwhelmed and felt that some instructors did not have enough experience with LMS (such as Blackboard, Canvas) and online conference tools (e.g., Zoom) to engage students effectively. The student frustration was reflected in their remarks:

- *I have 3 classes that are 5-week courses and now I am not sure how I am going to attend my other class if my professor has not added information on Blackboard. When I have questions [for an in-person class] I would usually ask after class but now I have to email my professor and some professors do not answer back. I do not think it is fair that some assignments are not clear and professors do not answer & I must figure it out on my own and have my grade affected if I did not do it correctly due to unclear assignments.* (FGS; 20 years old; female; employed full-time; junior; Hispanic or Latino; Household income: $50,000 to $74,999; single)

These frustrations and challenges indicate that the students in our study valued consistency in the synchronous collaborative platforms and sufficient training for faculty in online content delivery, as well as student training in effective use of LMS.

In summary, our thematic analysis revealed two important themes on the technological disadvantages that underserved college students experienced during the abrupt transition to online learning. First, the technological disadvantage was multifaceted and not only technological (i.e., barriers with computer devices and Internet access). Other emerging factors include difficulty in accessing online learning due to family responsibilities (taking care of the young or elderly), employment obligations (working from home and changing work shifts), or instructional ambiguity (lacking clear

instruction or timely communication from faculty members). Second, the two levels of the digital divide (ICT access and use) were associated with other factors stemming from the lockdown and quarantine mandate during COVID-19. The lack of or insufficient access to the Internet was due not only to financial reasons (e.g., no money to pay for high-speed Internet) but also to contextual factors such as the increasing demand for Internet access by members in the same household.

7. DISCUSSION, CONTRIBUTION, AND IMPLICATIONS

We have employed mixed methods to identify whether and how college students from a minority-serving institution experienced the digital divide and digital inequality in their sudden transition to online classes in spring 2020 due to the COVID-19 lockdown. Our data analysis of 220 college students has shown that the digital divide and digital inequality persisted in online education. Moreover, our supplemental thematic analysis revealed that the technological disadvantages that underserved college students experienced were not simply technical, but deeply rooted in the contextual constraints of the lockdown in the global crisis.

7.1 Exposure of the Digital Inequality Between Underserved Students and Their Peers

Among the four types of digital barriers, slow Internet service was the most frequently experienced, as evidenced by 67.7% of the digital barriers reported. The second-most common barrier was technical problems with the computer software, hardware, and network, accounting for 16.9% of the total digital barriers. Slow Internet service and technical use problems became more relevant to online learners during COVID-19 when members of many families had to stay at home and use the Internet to perform their jobs or take online classes. As a result, students' learning experience and online class performance suffered. To overcome those challenges, some students expressed their urgent need to have access to a safe study location with fast Wi-Fi or to have faster Internet at home.

Our qualitative results show that about one third (33%) of the respondents experienced digital barriers, as shown in Table 3. Surprisingly, a higher percentage of White/Caucasians and Asian/Pacific Islanders experienced digital barriers, at 52% and 41%, compared to 31% of Hispanic/Latinos and 25% of Black/African American students. These findings could be partially explained by the low-income or first-generation status of some of the students. A further analysis of the effect of the intersection between income and race on digital barriers will provide further insights.

Scholars have agreed upon the common causes for the digital divide, which include income, education, and ethnicity (see Table 1). In our study, most of the participants were underserved students, including 70% students of color (Black/African American or Latinx) and 62.7% students who reported themselves as the first college students in their families. The sudden increase in the use of academic technologies and online learning platforms at home during COVID-19 clearly exposed the digital barriers experienced by these underserved students. This finding is worrisome, as research on digital inclusion has highlighted that ICT access and proficiency are critical for underserved populations to improve their lives and life chances (Notley, 2009). As revealed in our supplemental analysis, the number of household members needing Internet access and computer resources simultaneously was one major reason for digital barriers during COVID-19. Further research on family size and its effect on the digital divide is likely to generate additional insights.

7.2 Practical Implications and Guidelines to Promote Digital Equity

With the increasing adoption of online learning by higher education institutions during the COVID-19 crisis, we realized the urgent need to study the digital divide in the new online learning modality. Our study of underserved college students in e-learning at the beginning of the pandemic showed two levels of the digital divide, but we did not find a significant association between students' experiences of digital barriers and their socio-economic factors (e.g., first-generation status and household income). Our supplemental thematic analysis revealed multiple causes for the technological disadvantages of underserved students in online learning.

The study findings offer practical guidelines for promoting digital equity among underserved students in higher education (refer to Table 6). Puigjaner (2016) proposes five dimensions of digital equity: (1) access to technology resources; (2) access to high quality digital content; (3) access to high quality, culturally relevant content; (4) educators skilled in using these resources effectively for teaching and learning; and (5) opportunities for learners and educators to create their own content. Our study highlights the urgency in implementing free, university-wide technology programs such as laptop check-outs and portable Wi-Fi. Such programs support the first dimension of digital equity by providing the technological resources for students access the information in the learning networks (e.g., Blackboard, Canvas, YouTube videos, and LinkedIn Learning).

Moreover, our study shows that technological disadvantages of underserved students were caused not only by technical factors but also by contextual constraints, such as personal circumstances, employment obligations, or family responsibilities. Institutions and educators should consider these factors when designing online teaching guidelines and developing digital skills training programs for this student population.

Finally, our study participants expressed the need for clarity in online course instructions and for prompt feedback from their instructors through electronic channels. This need suggests that institutions consider providing instructors and staff with adequate technical training and resources and encouraging them to pay more attention to societal inequities in online education (Hall et al., 2020). Doing so would help achieve the final two dimensions of digital equity.

In summary, our study distinguished two levels of the digital divide in online education and revealed the multifaceted causes for the digital inequalities that underserved college students experienced during the global crisis. Based on the findings, our study recommends some solutions to help higher education institutions and educators close the digital divide and enhance digital equity. These recommendations are summarized in Table 6. It is important to note that some suggestions such as that for clarity in course instruction would benefit all students, not only underserved students.

Causes of Technological Disadvantages	Recommended Solutions
Instructional ambiguity	Provide instructors with training in using education technologies; provide instructors with training on culturally relevant pedagogies.
Personal factors (e.g., health, learning style)	Be mindful of individual student challenges and provide flexibility in course assignments to allow students to complete learning tasks at their own pace.
Multifaceted factors (social, family, employment)	Recognize and accommodate online learning needs of adult students, particularly those who are employed and who likely balance multiple commitments (employment, family, college).
Technical factors (e.g., lack of technology resources)	Periodically assess students' needs in the areas of access to and use of ICT for online learning; provide technology resources and support to meet their needs.

Table 6. Recommendations to Overcome Technological Disadvantages in Online Learning

8. CONCLUSIONS

This study, focusing on underserved college students and their experiences with online learning at the beginning of the COVID-19 pandemic, offers valuable insights into digital divide research and e-learning practices. While the digital divide persists in online education, it can no longer be described in binary terms (e.g., "Have" or "Have not"). Instead, understanding the complexities of technology access and digital skills among underserved students demands consideration of multifaceted factors. Beyond mere access, digital inequality in online learning—such as unequal opportunities and engagement—encompasses situational elements (such as familial and employment contexts) and instructional factors (including course design and instructor expertise). The study's findings not only inform educators and institutions on strategies to bridge the digital divide in online education and foster digital equity for underserved students but also contribute to information systems research and educational practices by offering a nuanced understanding of the digital disparity in online learning.

This study has several limitations. First, the findings are potentially limited by the research site and the sample size. Second, the data were collected during the first two weeks of the university's transition to a completely online modality in spring 2020. As students have accumulated experience over time, certain barriers may have decreased. In this regard, we suggest one promising area for future research is to conduct a longitudinal study to measure student persistence and learning outcomes in online education in the face of digital barriers.

Based on this study, future research can focus on underserved female students. It is important to recognize the additional load on female students in e-learning. As Stone and O'Shea (2019) highlight, many women are carrying a largely invisible yet emotional and time-consuming load while pursuing their higher education online. This study reveals that adult online learners not only experienced technological challenges as they often had multiple identities, including being a full-time employee or a family caregiver as well as a college student. This new research will extend the research call by Stone and O'Shea (2019) to understand and improve gender equity, particularly for mature-age students, in the online learning environment.

The pivotal role of ICT in education and skills domains has been clearly demonstrated in a RAND report (Grand-Clement, 2017). Higher education institutions cannot assume that college students have the technical resources and digital proficiency required to be effective learners in online learning environments. As shown in our study, persistent gaps in the ICT access and use placed many underserved students at a disadvantage when it came to finding the technology resources and developing the digital skills to thrive in the abrupt transition to completely online instruction. According to a National Digital Inclusion Alliance (2019) report, "Digital equity is necessary for civic and cultural participation, employment, lifelong learning, and access to essential services." An institutional culture that recognizes the digital barriers in student e-learning and seeks to alleviate some of the challenges will contribute to greater equity between underserved students and their peers. Recognizing the presence of the digital divide and digital inequality in online education, and the associated factors, is the first step towards helping underserved students achieve academic continuity in times of crisis. In the long run, building a more equitable online learning environment by accounting for diverse backgrounds and the technical needs of students will enable more underserved students to participate equally and succeed in higher education.

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AUTHOR BIOGRAPHIES

Xuefei "Nancy" Deng is a professor of information systems at California State University, Dominguez Hills. She received her Ph.D. in Information Systems from Carnegie Mellon University. She is the co-PI of a $5.3M grant awarded by the U.S. National Telecommunications and Information Administration (NTIA). Her research interests include crowdsourcing, digital and social media, STEM career, first-generation college students, and distance education. Her research has been published in *MIS Quarterly*, *Journal of Management Information Systems*, *Journal of the Association for Information Systems*, *Information Systems Journal*, *Information Technology & People*, *Decision Support Systems*, and *Journal of Information Systems Education*, among others.

Sherine El Hag is currently a full-time lecturer at California State University, Dominguez Hills (CSUDH). She has a Ph.D. in Economics, and an MBA from Claremont Graduate University. Sherine has sixteen years' teaching experience. She held non-academic supervisory positions as a banker and senior economist. She is an advisory board member at South Bay Institute at CSUDH. She has several research publications in international money and finance. She is a grant recipient (Principal Investigator) from SUNY in 2014 and is a co-PI for a grant in 2021 at CSUDH. Sherine is a frequent presenter and reviewer at esteemed conferences.

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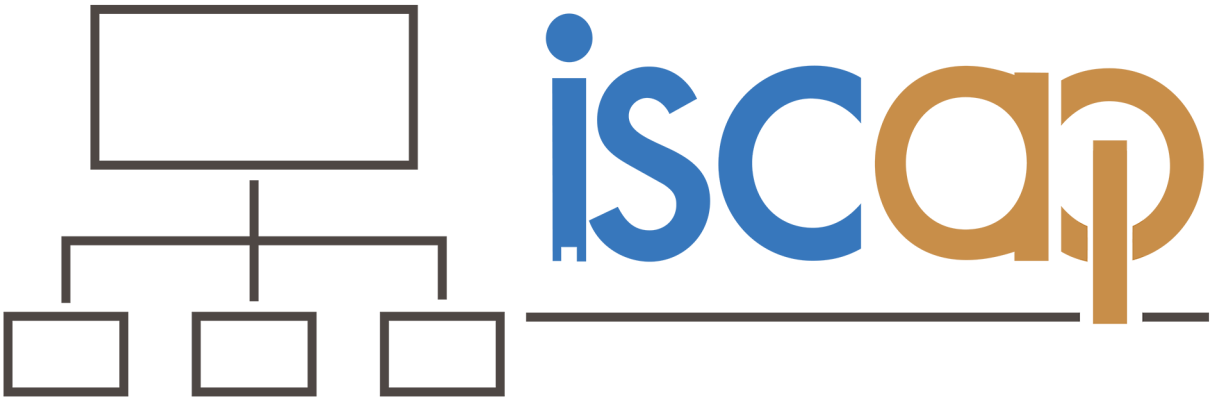

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