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Digital Divide Issues Affecting Undergraduates at a Hispanic-Serving Institution during the Pandemic: A Mixed-Methods Approach

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Abstract: Before COVID-19, digital divide research among college students was scarce, reinforcing the idea that technology access was nearly universal, with few demographic differences. Pandemic-era research found some technical challenges, but most studies were conducted nationally or at research-intensive (R1) universities, indicating a paucity in research among underrepresented populations, notably at Hispanic-Serving Institutions (HSI). This mixed-methods study aimed to assess digital inequities and pandemic-related technological challenges at an HSI, with high percentages of low-income and first-generation students. This study also sought to determine if findings were consistent with national and R1 research. We surveyed a representative sample of 2188 undergraduates and conducted semi-structured interviews with 26 students. Results showed many students had inadequate technology. Just 79% had the optimal combination of smartphone plus laptop or desktop, with first-generation, low-income, Black, and older students significantly less likely to have this combination and often having to share devices within their households. Internet quality significantly affected all coursework-related challenges, as almost half of students with unstable internet reported trouble completing assignments compared to 20% with stable internet. Finally, results suggest the digital divide may be more prevalent at HSIs than at previously studied institutions, while also offering insight into how these challenges affect similar universities.

Keywords: digital divide; undergraduates; internet access; technology access; Hispanic-Serving Institution; underserved and vulnerable students



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1. Introduction

As COVID-19 turned homes into classrooms nearly overnight in Spring 2020, the magnitude of the impact of remote instruction became a pressing concern at every university. Along with concerns about basic needs, questions about the adequacy of students' computers and internet connections became urgent and continued to be so into the following academic year. Pre-pandemic digital divide research among college students, although sparse, suggested device access was no longer a problem. Although, for underserved students in particular, reliable internet remained an issue. How these findings on connectedness would translate to a Hispanic-Serving Institution (HSI) in the United States, where more than half of students are low-income enough (i.e., family income of \$60,000 or less) to qualify for Pell Grants remained unknown. [1]. Raising further questions was that most pre-pandemic research on the adequacy of technology among college students was conducted nationally or at research-intensive universities (R1) [2], which collectively may fail to properly portray the technological inequities faced by underserved students.

Campus computing resources have offered an avenue for students who have poor internet or lack the necessary devices (for context, during the fall 2019 semester, our library computer lab recorded 132,996 sessions totaling almost 100 h). However, once pandemic restrictions eliminated campus Wi-Fi and computer labs and other places offering Wi-Fi

were closed, we launched an in-depth study of undergraduates' reported barriers at an HSI to completing coursework and the extent to which the students were affected by the digital divide, i.e., the inequitable access to technology and its effective use.

1.1. Literature

The awareness of, and concerns about, inequalities in access to information, and the means to produce and disseminate information, is hardly new [3–5]. With the dawning of the internet age, “digital divide” became a well-known phrase, one that has evolved significantly as information technology has become embedded in day-to-day life [6]. Today, scholars view the digital divide as having multiple levels. Although this study focuses on the first-level divide, some background on the other two levels is important for context.

1.1.1. First-Level Divide

The “first-level” of this divide, i.e., inequality in access to devices and internet connections, has received significant attention from researchers during the past three decades [7–12]. However, as the price of computing devices dropped and ownership of smartphones and tablets became widespread, an annual survey by the United States Census Bureau (though over the years different methodologies have been used to collect data) found that between 1980 and 2018, the number of homes in the United States with access to a device capable of connecting to the internet grew from 8% to 92%, and at least 85% of households have broadband internet connection [13].

Although inequalities in device ownership and internet access have lessened, a first-level divide still exists, primarily for low-income or ethnically and racially diverse families, especially concerning internet access. For example, more than 40% of households with incomes below \$30,000 have neither broadband service nor a traditional computer [14]. Moreover, according to the U.S. Census Bureau, although 92.3% of Asian households have access to broadband internet, only 77.7% of Black households enjoy that same access [13]. As concerning as this is, it is only part of a larger picture. Katz [15] has argued that, in contrast to the dichotomous framing of the digital divide, a state of “under-connectedness” exists because of any number of factors including inadequate devices, device sharing, and a loss of internet service because of financial circumstances. This was further exacerbated by the pandemic [16].

As information and communication technologies (ICT) have advanced, access definitions expanded to include the means to maintain devices (e.g., broken hardware, data limits, and connectivity problems). For those unable to sustain access to ICTs equal to the task of utilizing the modern internet, the digital divide has persisted [12,17–20]. Given the increasing importance and integration of technology into education, research into the impact of this first-level divide on academic achievement is well documented, primarily at the K–12 level [21–26]. Over time a consensus has emerged that access to devices, though not without some drawbacks, is an important factor to academic success in the increasingly digitized classrooms of most colleges and universities.

1.1.2. Second-Level and Third-Level Divides

Viewing the digital divide as simply a matter of access to technology “is too narrow at best and quite problematic at worst” [27]. As Chen observed, there is more than one single divide, and although access to the internet is undoubtedly important, “what [individuals] use it for, and the returns they gain” represent “multidimensional and multilayered” digital divides of their own [28]. As a result, two other levels at which the divide may be found are as follows: a second-level inequality in “skills to use technologies in ways that enhance professional practices and social life” [29] (para. 86), that may be even more significant than that of access [8,30–32]; and a third-level inequality of outcomes related to social status and connectedness which are tied to internet access [28,33,34].

Indeed, some of the same factors that contribute to inequalities in internet access (e.g., race and ethnicity, educational attainment, and socioeconomic status) also contribute

to disparities in the adoption, use, acquisition of skills, and outcomes of technology use [5,28,35–40]. Moreover, it has been argued that “existing social stratifications may even be reinforced” [8] (p. 2704).

1.1.3. Higher Education Research

Digital divide research in higher education, though sparse before the pandemic [41,42], has reported device ownership among U.S. students as exceeding 90% in recent years, with few demographic differences [20,24,43–46]. However, reliance on smartphones has been shown to be greater among non-White, lower income and first-generation students [43,45]. Pre-pandemic research findings on internet access and quality have been more uneven. Educause, which has been surveying tens of thousands of U.S. students for more than a decade, has found 61–72% of students living off campus rating their internet quality as good or excellent compared to 46–51% of those living on campus. Although most students report excellent Wi-Fi experiences in libraries and classrooms, outdoor Wi-Fi and dormitory connections are reported as subpar [43,47].

Pre-pandemic higher education research has also found a new aspect of the first-level divide: technology maintenance problems. Gonzales et al. found that about 20% of students “had difficulty maintaining access to technology (e.g., broken hardware, data limits, connectivity problems, etc.). Students of lower socioeconomic status and students of color disproportionately experienced hardships, and reliance on poorly functioning laptops was associated with lower grade point averages” [20] (p. 750).

Since the pandemic, more technology access challenges have emerged despite campus programs to loan equipment. For example, administrators surveyed by Educause in April 2020 reported that 36% of students had moderate to extreme difficulty accessing the internet [48]. Furthermore, two recent California studies found that more than 12% of students lacked either adequate devices or internet access with higher proportions among Black and Latinx (we use Latinx, Hispanic/Latino/Latina, or Hispanic alone consistent with the source’s terminology) students, community college students, and low-income students [49,50]. Other studies also uncovered technology access challenges which more severely affect first-generation students and/or underrepresented groups [42,51,52].

However, beyond device and internet access, and maintenance challenges, technology barriers continue amongst college students at the second and third levels of the divide, including use in the classroom, technology proficiency, and differing achievement in online courses, with underserved groups more commonly on the “wrong” side of the divide [51,53–57].

This study was prompted by research suggesting that data differ by types of institutions. For example, Galanek et al. found that undergraduates at masters-level and doctorate-level private universities were less likely to report good or excellent overall technology experiences [47], whereas recently, Jaggars et al. found more inadequate technology at non-R1 campuses than at R1 institutions [42]. Meanwhile, Buzzetto-Hollywood et al. reported lower device access at historically Black universities [58]. Although we could find no pre-pandemic research on technology adequacy at Hispanic-Serving Institutions (HSI), substantial numbers of students in two recent studies in California, which has a large number of HSIs, reported technology challenges [49,50].

2. Methods

2.1. Study Aims and Research Questions

Past literature has shown that technology inequities and the digital divide affect underrepresented groups of college students, but most studies regarding this topic were conducted nationally or at R1 universities. The paucity of research focusing on Hispanic-Serving Institutions, both before and during the pandemic, prompted our overall research goal: determining whether undergraduates at an HSI with large numbers of low-income and first-generation students had adequate device access and internet quality. We also

sought to understand how the pandemic created technology-access challenges for both coursework and remote learning. More specifically, we addressed the following three areas:

- RQ1: Access to devices, device reliability and internet quality.
- RQ2: Coursework-specific technology challenges.
- RQ3: Challenges related to attending school from home.

We also sought to understand if these issues were comparable to those found in studies nationally and at R1 institutions. Finally, we wanted to explore how specific demographic factors affected technology challenges, which may shed light on issues facing these underserved and understudied populations. To explore this topic, the following demographic items were key for our analysis:

- Race and ethnicity;
- Gender;
- Age (e.g., traditional vs. non-traditional students);
- Enrollment status (e.g., part-time vs. full-time);
- First-generation status (whether the student was the first in their family to attend college);
- Pell Grant eligibility, as a proxy for low-income;
- Academic success risk (low-income and first-generation students).

2.2. Participants and Procedures

This study utilized a mixed-method approach through an online survey (Appendix A) and semi-structured interviews. The quantitative portion is a subsection of a campus-wide student survey conducted in December 2020. Emails with the study link were sent to the nearly 40,000 enrolled students. Unduplicated responses were received from 2543 undergraduate and 460 graduate students (total response rate of 8%) who answered all or part of the survey and provided a campus identification number. The survey had three sections: satisfaction with campus responses to the pandemic and issues related to housing and financial assistance; issues with technology and working from home; and student learning and academic readiness for the upcoming spring semester.

Because a portion of the digital divide includes technology access, only responses from undergraduates who indicated which devices they used during the online academic year were analyzed. Demographic data were compiled through the campus office of Institutional Research & Analytics. In total, this study assessed responses from 2188 undergraduates.

To complement the quantitative responses, 26 undergraduates, recruited via convenience sampling, participated in semi-structured interviews during the fall semester. Participants were asked questions on technology and working from home similar to those in the survey, but they were prompted to elaborate on any issues. The interviews averaged 14.8 min, not including informed consent and introductions. All responses were audio recorded and transcribed for data analysis. Participants were not offered an incentive for either the quantitative or qualitative portion of this study. All procedures were approved by the Institutional Review Board at California State University, Long Beach.

2.3. Measures

The following outcomes were assessed in both the survey and semi-structured interviews. In the survey, participants were presented the question and response options in a close-ended format in which they could select their best response(s). For the interviews, participants were read questions (e.g., “What type of technology-related issues do you have with completing schoolwork?”) and asked to elaborate on their experiences through an open-ended dialogue.

2.3.1. Access to Technology

Participants were asked what devices were available to them; if they shared their devices with others; their awareness and usage of the campus’ Student Laptop/Hotspot Loan Program; device-specific issues; and the quality of their internet.

2.3.2. Technology-Specific Challenges

Participants were asked to select technology-specific challenges that resulted in difficulties completing coursework. Options included accessing live lectures (e.g., Zoom calls), communicating with instructors and classmates, watching pre-recorded videos (e.g., asynchronous courses), completing assignments and readings, and using the campus learning management system (LMS). Furthermore, participants were asked to rate their comfort in using the LMS based on the following items, “Very confused”; “Comfortable”; and “Proficient.”

2.3.3. Challenges of Working at Home

Participants were asked to select specific challenges they encountered while working from home. These included assuming responsibility for childcare or family needs, dealing with unanticipated noises or distractions, and having insufficient workspace.

2.4. Data Analysis

All data analysis was completed using SPSS version 27. Descriptive statistics and frequencies were calculated for relevant study variables. Chi-squared tests were calculated to determine possible disparities in key study variables that may have existed between predictors.

This study had 1538 females and 648 males. Classification included 18% freshmen, 16% sophomores, 26% juniors, and 40% seniors, with 87% enrolled full time. Ages ranged from 17 to 67 ($M = 23.04$; $SD = 6.42$), and 79% of the sample were considered traditional students (under 25). Additionally, 34% of participants were first-generation and 56% of the overall sample were Pell-eligible students. Students who identify as Hispanic/Latino/Latina had the highest representation, at 45%. Compared to the university population, our sample was representative across all categories, except for gender, with this study’s sample consisting of 70% females against 57% for the university (Table 1).

Table 1. Study sample demographics compared to university population.

	Study Sample (%)	University Population (%)
Classification		
Freshmen	18	17
Sophomores	16	15
Juniors	26	26
Seniors	40	42
Race/Ethnicity		
Hispanic/Latino	45	46
Asian	19	21
White	17	16
Black	4	4
Two or more races	5	5
International	7	6
Unknown or other	2	2
Gender		
Female	70	57
Male	30	43
Age		
Under 25	79	80
25 & older	21	20
Enrollment		
Full-time	87	85
Part-time	13	15
First-Generation		
Yes	34	31
No	66	69
Income		
Pell-Eligible	56	57
Non-Pell-Eligible	44	43

3. Results

3.1. Access to Technology

RQ1 aimed to understand students' access to technology during the transition to alternative modes of instruction, with a particular focus on the types of devices, their reliability, and the quality of their internet (Table 2). The vast majority of our sample had access to either a laptop (89%) or smartphone (82%). Less than a third (31%) of participants had access to a tablet or Chromebook, and 27% had a desktop computer. Past literature has suggested that students with access to a smartphone and a laptop or desktop computer found their technology to be best for academic success [44,45,54]. Thus, we operationalized those with a smartphone and either a laptop or desktop computer as those with "optimal technology," accounting for 79% of our sample. Additionally, 84% had access to more than one device, and 15% of participants shared their device. For device reliability, 30% indicated that their devices stopped working at one point during the semester, and 36% reported equipment needs or Wi-Fi issues at home.

Although results from the survey suggest that device access is high, the qualitative portion uncovered potential issues regarding device access, even if students have technology at their disposal. Some remarked that their device did not have the proper hardware or software to be successful in their courses (e.g., the lack of a camera or necessary programs such as word processors, statistical packages, or presentation tools). For software issues, students who normally relied on university resources, such as the library or on-campus computer labs for their work, now had to resort to using personal devices that were not up to par. One student expressed, "I just wish my software would be fast. I used to rely a lot on the computers [on campus]. They were more updated; they had the latest software all the time." Another key finding from the interviews was that students suddenly needed to purchase newer equipment. As one student explained: "I've had my laptop since 2014, but I upgraded this year because I couldn't get Zoom to download . . . I really did not want to upgrade my old laptop functioned enough if I needed to write a paper but working online 24/7 just wasn't doing it." Another student who bought a new laptop echoed these sentiments: "I used an older laptop that I guess wasn't really cutting it. I was using a Chromebook."

Table 2. Technology Access.

	N	Laptop (%)	Smartphone (%)	Desktop (%)	Tablet (%)	Optimal Technology (%)	Shared Device (%)	Borrowed Device from Campus (%)	Equipment Challenge (%)	Device Not Working (%)	Unstable Internet (%)
Total Sample	2188	89	82	27	31	79	15	8	36	30	29
Race/Ethnicity											
Hispanic	979	88	81	22	29	78	20	9	35	32	29
Asian	417	89	84	36	36	83	10	8	40	30	30
White	392	91	87	29	29	85	11	4	37	29	27
Black	85	87	77	25	29	69	11	9	39	20	19
2 or more races	117	89	86	33	34	84	5	4	32	29	31
Gender											
Female	1538	91	83	20	32	80	16	9	37	31	31
Male	648	84	82	42	29	79	14	6	34	27	24
Age											
Under 25	1730	90	85	25	30	82	14	6	37	31	30
25 and older	458	85	73	32	35	68	19	15	35	25	24
Enrollment											
Full-time	1913	89	83	26	31	80	15	7	37	30	30
Part-time	275	88	76	30	35	73	16	11	31	26	22
First-Generation											
Yes	659	85	77	25	29	72	21	12	35	30	30
No	1290	91	86	28	32	85	12	5	36	30	28
Income											
Pell-Eligible	1207	87	81	24	31	77	18	10	38	31	30
Not Pell-Eligible	968	90	85	29	32	82	12	4	35	29	27
Academic Success Risk											
Yes	521	85	75	23	29	70	21	13	36	31	30
No	735	91	87	30	32	85	11	4	35	29	26

Note: Tablet includes Chromebooks; Unstable internet = bad or unpredictable; Optimal Technology = smartphone and laptop or desktop; Academic success risk (yes) = first-generation and Pell-eligible. Bold numbers are significant at $p < 0.05$ for the difference between groups. International students were omitted because we could not verify their race or ethnicity.

Although concerns about the quality of devices and software were expressed, only 8% of students borrowed equipment from the university, despite 79% being aware of the university's Student Laptop/Hotspot Loan Program. When looking at outcomes that are influenced by demographic predictors, sharing and borrowing devices were impacted by income, first-generation status, and age. Pell-eligible ($\chi^2(1, N = 211) = 11.52, p < 0.001$) and first-generation students ($\chi^2(1, N = 141) = 33.45, p < 0.001$) had greater incidences of sharing their devices with someone else. Furthermore, Pell-eligible ($\chi^2(1, N = 124) = 25.77, p < 0.001$) and first-generation students ($\chi^2(1, N = 77) = 31.05, p < 0.001$) were more reliant on borrowing equipment from the university program. Conversely, very few continuing-generation students (5%) and non-Pell-eligible students (4%) utilized these resources. Students 25 and older had higher percentages of sharing devices ($\chi^2(1, N = 85) = 4.79, p < 0.05$) and utilizing the university's equipment-loan program ($\chi^2(1, N = 70) = 47.27, p < 0.001$).

Furthermore, internet quality varied greatly across our sample. In total, 29% of participants described their internet as either bad or unpredictable, 57% deemed it as OK, whereas only 14% considered their internet quality to be great. To better understand the impact of internet quality, we operationalized those with "unstable" internet as either bad or unpredictable and "stable" internet as either OK or great. Students who were of traditional age ($\chi^2(1, N = 517) = 7.07, p < 0.01$), female ($\chi^2(1, N = 469) = 9.41, p < 0.01$), or full-time ($\chi^2(1, N = 564) = 6.22, p < 0.05$) were significantly more likely to report unstable internet quality compared to their counterparts. During interviews, students often mentioned internet quality issues. As one student observed: "So it's supposed to be high-speed, but it's really not. It lags, it stops... it's really annoying." Another bemoaned, "I'm trying to do so much, it's gotten to the point where half of the time my Zoom freezes it goes out probably once or twice a week." In addition, students said there were more people on the connection than before, with students' siblings, parents, or roommates simultaneously working from home. Sample responses included, "Although [the internet connection] is good, if there are a lot of people in the house, it tends to slow down" and "I have two roommates, so all three of us are in school and we're all doing online learning."

3.2. Coursework-Specific Technology Challenges

RQ2 aimed to assess coursework-specific technology challenges students faced (Table 3). Across the sample, only 17% reported no coursework-specific technology challenges. The most common challenge was accessing live lectures (e.g., Zoom lectures during synchronous courses), which affected more than half the sample (58%). Other, less common challenges included communicating with instructors or classmates (42%), viewing videos (e.g., pre-recorded lectures) (29%), and completing assignments (27%), using the campus LMS (20%) or required readings (14%).

Similar to access to technology, income was a key predictor for technology-specific challenges. Those who were Pell-eligible had more difficulties in viewing videos needed for courses ($\chi^2(1, N = 370) = 5.88, p < 0.05$), completing assignments ($\chi^2(1, N = 362) = 10.17, p < 0.01$), and using the LMS ($\chi^2(1, N = 262) = 5.80, p < 0.05$). A higher proportion of traditional-aged students had challenges accessing live lectures ($\chi^2(1, N = 1041) = 25.10, p < 0.001$) and using LMS ($\chi^2(1, N = 360) = 5.41, p < 0.05$) compared to non-traditional students. Similarly, more full-time students had issues accessing live lectures ($\chi^2(1, N = 1118) = 6.13, p < 0.05$), viewing videos ($\chi^2(1, N = 567) = 10.16, p < 0.01$), and using LMS ($\chi^2(1, N = 397) = 8.90, p < 0.01$). Regarding gender, females reported more issues accessing live lectures ($\chi^2(1, N = 916) = 8.97, p < 0.01$) than males.

In addition to the demographic predictors, we sought to investigate how internet quality may be linked to the technology-specific challenges. Across all technology-specific challenges, those with unstable internet were significantly more affected than students whose internet was stable. Accessing live lectures was a challenge for 58% of the sample, but 80% of participants with unstable internet reported this to be problematic compared to 49% with stable internet. Moreover, a greater proportion of users with unstable internet reported

issues with communicating with others ($\chi^2(1, N = 326) = 35.70, p < 0.001$); watching videos ($\chi^2(1, N = 265) = 83.13, p < 0.001$); using the LMS ($\chi^2(1, N = 207) = 98.04, p < 0.001$); and reading required materials for their courses ($\chi^2(1, N = 139) = 48.45, p < 0.001$). Perhaps most worrying is that only 20% of those with stable internet reported issues in completing assignments, whereas nearly half (46%) with unstable internet had struggles doing so. When looking at the total sample, 27% had problems completing assignments, which appears modest; however, it is clear that completing assignments may be linked to the quality of the students' internet. In addition to negative impacts on grades, being unable due to complete assignments can also lead to distress. As one student explained, "... if my Wi-Fi drops and I'm in the middle of something and it doesn't save or something like that. Doing every single thing online, you're always like, 'Oh God, is it going to drop in between?'"

Table 3. Coursework-Specific Technology Challenges.

	<i>N</i>	Accessing Live Lectures (%)	Viewing Videos (%)	Communicating (%)	Completing Assignments (%)	Reading (%)	Using LMS (%)
Total Sample	2188	58	29	42	27	14	20
Race/Ethnicity							
Hispanic/Latino	979	60	30	40	29	13	22
Asian	417	55	24	44	25	16	16
White	392	44	33	44	28	16	20
Black	85	47	26	40	26	12	18
Two or more races	117	61	24	43	24	12	21
Gender							
Female	1538	60	29	41	27	14	20
Male	648	53	27	45	29	15	19
Age							
Under 25	1730	60	29	43	28	14	21
25 and older	458	47	25	41	26	14	16
Enrollment							
Full-time	1913	58	30	42	28	14	21
Part-time	275	51	20	42	26	15	13
First-Generation							
Yes	659	56	29	39	29	15	20
No	1290	59	28	44	27	13	20
Income							
Pell-Eligible	1207	57	31	41	30	15	22
Non-Pell-Eligible	968	58	26	44	24	13	18
Academic success risk							
Yes	521	57	30	39	30	15	21
No	735	61	26	45	24	12	18
Optimal Technology							
Yes	1735	58	28	42	27	15	20
No	453	57	30	45	29	12	19
Internet Quality							
Unstable	625	80	42	52	46	22	33
Stable	1558	58	23	38	20	11	14

Note: Bold numbers are significant at $p < 0.05$ for the difference between groups.

3.3. Challenges of Working at Home

RQ3 aimed to assess the challenges students experience while attending class at home (Table 4). A majority of participants (72%) reported unanticipated noise as a challenge. Over half (52%) experienced insufficient workspace, and 31% expressed challenges regarding childcare or other family-related obligations. Only 18% of our sample reported zero working from home challenges.

Table 4. Working from Home Challenges.

	N	Childcare/Family Needs (%)	Unanticipated Noise (%)	Insufficient Space (%)
Total Sample	2188	31	72	52
Race/Ethnicity				
Hispanic/Latino	979	39	77	57
Asian	417	27	69	49
White	392	23	70	51
Black	85	28	68	45
Two or more races	117	23	69	49
Gender				
Female	1538	32	75	55
Male	648	27	67	47
Age				
Under 25	1730	31	74	53
25 and older	458	31	66	48
Enrollment				
Full-time	1913	31	73	52
Part-time	275	31	69	52
First-Generation				
Yes	659	4	72	56
No	1290	25	73	50
Income				
Pell-Eligible	1207	37	76	56
Non-Pell-Eligible	968	2	69	47
Academic-success risk				
Yes	521	44	75	60
No	735	22	70	48
Optimal Technology				
Yes	1735	30	74	52
No	453	34	66	51

Note: Bold numbers are significant at $p < 0.05$ for the difference between groups.

Inequities from working at home were highly prevalent for Pell-eligible, first-generation, female, or Hispanic/Latino/Latina students. Pell-eligible students had a higher incidence of unanticipated noise challenges ($\chi^2(1, N = 912) = 13.06, p < 0.001$) compared to non-Pell-eligible students, as well as more concerns about insufficient space ($\chi^2(1, N = 681) = 17.86, p < 0.001$). Furthermore, Pell-eligible students were more likely to experience childcare or family challenges ($\chi^2(1, N = 451) = 56.41, p < 0.01$). Similarly, a higher proportion of first-generation students experienced issues with insufficient space ($\chi^2(1, N = 372) = 7.45, p < 0.01$) and childcare or family needs ($\chi^2(1, N = 269) = 53.61, p < 0.001$). Students who are deemed most at risk for academic success (i.e., Pell-eligible and first-generation students) were twice as likely to report childcare or family challenges ($\chi^2(1, N = 229) = 69.23, p < 0.001$) compared to students who were not at risk. Collectively, female students had more issues with childcare or family needs ($\chi^2(1, N = 499) = 7.07, p < 0.01$), unanticipated noise ($\chi^2(1, N = 1150) = 15.54, p < 0.001$), and insufficient space ($\chi^2(1, N = 838) = 10.48, p < 0.01$). Finally, across all racial and ethnic demographics, Hispanic/Latino/Latina students had the highest percentage of challenges of working at home.

Interviews offered insight into how these challenges negatively impacted students' ability to complete their coursework. Unanticipated noise and distractions often came from others in the home. Not only was this problematic for concentration, but it also affected students' participation during live lectures. Several students remarked that there was so much going on in the background that they were forced to have their camera off or be muted, which often complemented issues of insufficient space. One student explained, "Because I live with my family, when I'd work outside in a kitchen or the dining room, my family would try to talk to me, or they'd be doing their other work and we'd be disrupting each other." Another elaborated on the lack of space, but also mentioned that other obligations interfered with their work:

"There's a lot of chaos in my house. You have the dogs, you have other people working, and there's a lot of noise and the TV. There's a lot of distractions, so being able to focus on what you need to do isn't always easy. Also, not having a dedicated space for work can be

difficult because it's uncomfortable or it's too comfortable. It's not the best environment for necessarily focusing on what you need to do. And of course, if you look around the house like, 'Oh gosh, I need to do this or I need to do that.' There's always something else that needs to be done when you're in this space."

Finally, one key theme emerged from the qualitative data that was not captured in the survey: students struggled separating their academic and personal lives. As one student mentioned, "Working from home, there's no separation. You don't feel relaxed, and your room is no longer sacred, or your home is no longer relaxing." Another said, "It's hard to focus . . . pretty much my whole life is in this one room."

4. Discussion

The purpose of this study was to better understand the technology challenges undergraduates faced at a large, Hispanic-serving public university where 57% of students are low-income and almost a third are first-generation. We also aimed to determine how the results from our study compared to those reported among college students in national studies and at R1 universities. The results from this study offer insight into the digital divide inequities faced by the students at the 87 public, four-year Hispanic-serving campuses in the United States, which have a combined enrollment of more than 1.5 million students [59]. Additionally, we hope to open the door for future research involving universities that primarily serve underrepresented populations. This is especially important in light of the expectation that institutions of all stripes will continue to expand online learning options.

Students in our study were most affected by internet quality and device reliability and adequacy, with close to a third of them reporting problems with one or more of these issues. Although measures vary among studies, this high incidence of the first-level of the digital divide is more comparable to that found in a national study of college-bound high school students [23] or among K–12 households in California [60], than what is found among college students in nationwide studies and at R1 institutions.

More specifically, 21% of students in our sample lacked the optimal device combination of a smartphone and either a laptop or desktop, and 3% reported having only a phone and/or tablet. Comparatively, a recent study ($N = 86,236$) of higher education in California reported that 10% of students across 23 California State University campuses, 15 of which are HSIs and none of which are R1s, reported "not having a computer readily available" [50] (p. 11). Meanwhile, that same study reported that 8% of students at the nine undergraduate University of California (UC) campuses, all but one of which is an R1 institution and five of which are HSIs, lacked computers.

Furthermore, the gap in internet quality was considerably greater but directionally consistent. Unstable internet access was reported by 29% of students in our study, compared to 17% of students nationally [61], 14% of students at other California State University campuses and 9% of students at UC campuses [50]. The nonprofit Education Trust—West found just 12% of students nationally ($N = 1010$), and overall, in California ($N = 321$), reporting "no, limited, or sporadic access to the internet" [49] (p. 4). Although it is hard to compare results of studies with differently worded questions and different sample sizes, there appears to be a consistent difference for device access and internet connectivity at HSI campuses with high percentages of low-income students relative to studies at R1 institutions (see Figure 1).

Although specific technology challenges were more prevalent among some demographic groups, coursework-related challenges were especially apparent among students with unstable internet access and the academically most at-risk students (those who are both low-income and first-generation). Significantly fewer at-risk students had access to the device combination that students say they consider optimal (i.e., a smartphone for convenience plus either a laptop or desktop for videos and learning management systems) than students who were higher income and whose parents went to college. These vulnerable students were also almost twice as likely to share devices. Even more troubling was that those with unstable internet had significantly more coursework-related struggles than

those with stable internet. This was most apparent when accessing live lectures, where 80% of participants with unstable internet reported this to be a problem compared to 58% with stable internet.

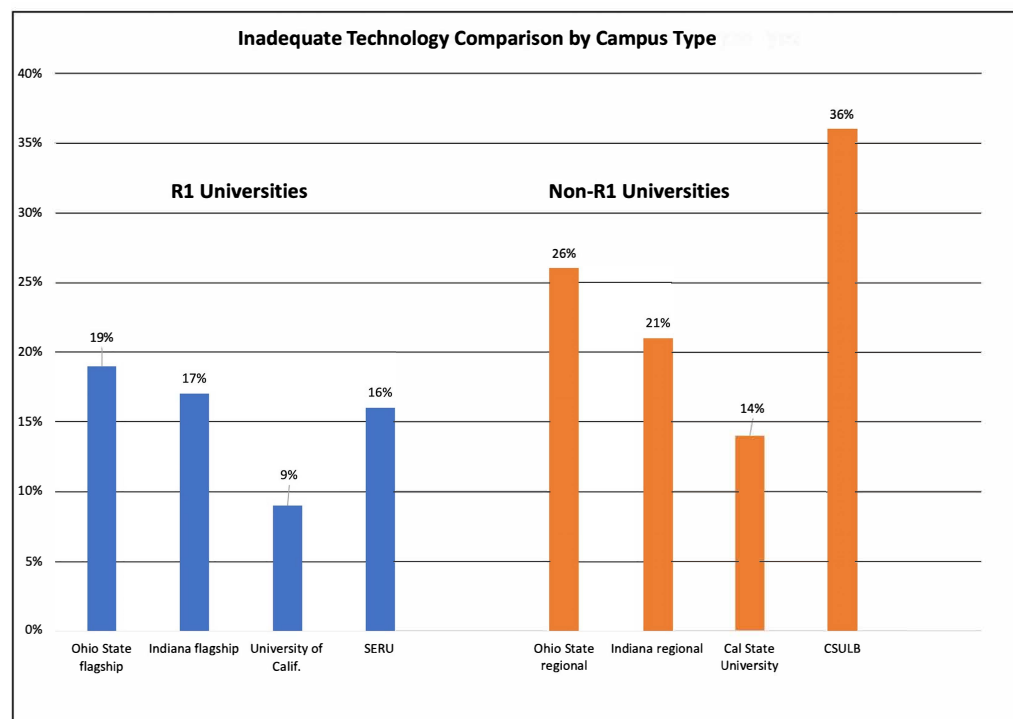


Figure 1. Inadequate Technology Comparison by Campus Type. Sources: Jaggars et al. [42], Reed et al. [50], Soria et al. [62]. SERU: Student Experience in the Research University Consortium.

In addition to the key results noted above, in contrast to the 2018 Galanek et al. study which found that “U.S. students appear to have overcome the problem of access to internet-enabled devices and reliable Wi-Fi” [45] (p. 7), we found significant percentage differences by gender, age, enrollment status, first-generation, and income:

- Gender: More women reported unstable internet.
- Age: More students under 25 had the optimal combination of devices, but they also reported more incidences of their devices not working and unstable internet. Older students were more likely to share a device or borrow technology from the university.
- Enrollment status: Full-time students were more likely to have the optimal device combination, but less likely to have stable internet access.
- First-generation: Students who were first in their family to attend college were less likely to have the optimal technology combination and more likely to share devices or borrow technology.
- Income: Pell-eligible students were less likely to have the optimal devices, and more likely to share or borrow technology.

Problems prompting the sharing of devices and the burdens of it were aptly described by one student, “Midway through the semester, I broke my computer, so I’ve been surviving on my iPad and trying to borrow my brother’s computer, but he’s also a full-time student.” Comments such as this illustrate the concept of the technology maintenance construct introduced by Gonzales in 2015 [19]. The construct proposes that “as access to information and communication technology peaks, the digital divide is increasingly characterized by the (in)ability to maintain access,” especially for lower income students and students of color [20] (p. 750). Thirty percent of our study respondents reported problems with devices not working, with the issue more prevalent among younger students and Black students.

Given the high incidence of technology inadequacy, coursework-specific technology challenges could be part of either the access-driven first level of the digital divide, or the skills-driven second level. This study found significant percentage differences in the challenges among several groups, especially for the most frequent problem, accessing live lectures:

- Gender: Women reported more difficulties accessing live lectures than men.
- Age: Younger students reported more problems accessing live lectures than older students.
- Race/Ethnicity: More Hispanic/Latino/Latina students and those of two or more races reported problems accessing live lectures.
- Enrollment status: Full-time students were more likely to report problems accessing live lectures and videos than part-time students.
- First-generation: These students were less likely to report difficulties communicating with instructors and classmates than students whose parents went to college.
- Income: Pell-eligible students were more likely to report challenges viewing videos and completing assignments than higher income students.

Limitations and Future Directions

The data in this study are cross-sectional; thus, we are unable to determine how challenges related to access to technology, technology-specific items, and working from home changed over time. Future studies should take a longitudinal approach to better assess how issues surrounding the digital divide develop, as well as a more in-depth analysis into the approaches that students take to overcome any barriers. In addition, this study took place during nearly universal remote classes. Although some of the technology issues are undoubtedly ameliorated by campus computing labs and Wi-Fi for students attending class in-person, the increasing move to hybrid and online classes raises many questions about whether students at universities with high numbers of low-income and first-generation students have the technology resources to thrive in hybrid and online courses.

Future studies would benefit from looking at the nuances within each level of the digital divide, as well as a clearer focus on, and the operationalization of, particular issues with access to technology. For example, our survey found that access to laptops was relatively high at 89%, but specific issues about these devices were only uncovered during the qualitative portion. Furthermore, more research is needed to better understand students' perceptions surrounding the quality of internet access.

Additionally, the literature suggests that lending equipment was a step taken by many universities in response to the pandemic [63,64]. Our university had a similar initiative, yet only 8% of our sample used the program, despite 79% being aware and about a third of students mentioning problems with devices not working (30%) or equipment challenges (36%). Although this lack of participation may only be applicable to this university, future research could examine the steps taken by universities to create effective equipment programs, as well as conduct studies with students to understand why they utilize such programs or not.

Our sample is limited to current undergraduates. Prior research has shown that the digital divide is a predictor for students' likelihood of attending college. Studies have found that access to high-speed internet is related to students' college application decisions and outcomes and their performance on the SAT [21,65], especially considering the recent decision to take the SAT all-digital by 2024. We recommend that future research investigates multiple education levels to better understand how access to technology, and its effective use, can lead to informed decision-making regarding higher education. Training in the effective use of these 21st-century tools, at all education levels, along with reliable, adequate, universal internet access is paramount if there is to be an equitable technological future because "digital access and proficiency [has] become essential for competitiveness in nearly every aspect of life" [66].

Finally, the national and R1 studies used in this study are not perfect comparisons and were used to provide context. Future research would benefit from looking at the differences among R1 universities, HSI, and other institutions comprising a variety of demographics.

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Appendix A

Technology Survey

- **Which of the following concerns have you encountered in navigating and completing your courses during alternative course delivery during the Fall 2020 term? (Select all that apply):**
 - Accessing technology (computer, internet, headphones, microphones, etc.) needed for your online classes
 - Social/Political environment
 - Academic advising
 - Workload
 - Food insecurity
 - Housing insecurity
 - Emergency grant aid
- **Are you aware that {redacted} has a program to assist students with access to technology (including internet access and devices)? (Yes/No)**
- **Are you currently using technology provided by {redacted}? (Yes/No)**
- **Which of the following types of devices do you have access to? Please choose all that apply:**
 - Chromebook
 - Laptop
 - Smartphone
 - Tablet
 - Desktop
 - Other
- **Do you share your principal device with others? (Yes/No)**
- **How much time per day do you usually have available to use your principle device?**
 - 1–2 h

- 3–4 h
- 5–6 h
- Unlimited time
- **If you found it challenging to work from your home, please indicate why (please select all that apply):**
 - Childcare/Family needs
 - Economic hardship
 - Equipment/Wi-Fi/Technology needs
 - Unanticipated noise/disturbances
 - Insufficient workspace
- **At home, which of the following methods gives you access to the internet? Please choose all that apply.**
 - Cellular data plan
 - High-speed internet
 - Hotspot
 - I do not know how I have home internet access
 - I do not access the internet at home
- **How would you describe the quality of the internet connection where you do most of your academic work that requires online access?**
 - Bad. My internet access is slow and works poorly most of the time.
 - Unpredictable. Sometimes the internet connection is good; sometimes it is bad.
 - Ok. Most days I have a good internet connection.
 - Great. I never have problems.
- **Have you had technological difficulties completing any of the following school-related activities? Please check all that apply.**
 - Accessing live lectures (e.g., Zoom)
 - Checking grades/homework (accessing, doing, submitting)
 - Required readings
 - Problems with device not working
 - Writing essays or papers
 - Using learning management system {name redacted}
 - Communicating with classmates
 - Watching videos (recorded lectures, assigned movies, etc.)
 - Communicating with instructor
 - Researching/Finding information

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