

Technology Problems and Student Achievement Gaps

A Validation and Extension of the Technology Maintenance Construct

Amy L. Gonzales

University of California Santa Barbara, Department of Communications

Jessica McCrory Calarco

Indiana University, Department of Sociology

Teresa K. Lynch

Ohio State University, Department of Communications

Accepted for Publication: August 2018

Full Citation: Amy L. Gonzales, Jessica McCrory Calarco, and Teresa K. Lynch.
Forthcoming. "Technology Problems and Student Achievement Gaps: A Validation and
Extension of the Technology Maintenance Construct," *Communication Research*.
<https://doi.org/10.1177/0093650218796366>

Abstract

How do physical digital inequalities persist as technology become commonplace? We consider this question using surveys and focus groups with US college students, a group that has better than average connectivity. Findings from a 748-person non-representative survey revealed that ownership and use of cellphones and laptops were nearly universal. However, roughly 20% of respondents had difficulty maintaining access to technology (e.g., broken hardware, data limits, connectivity problems, etc.). Students of lower socio-economic status and students of color disproportionately experienced hardships, and reliance on poorly functioning laptops was associated with lower grade point averages. Focus group and open-ended data elaborate these findings. Findings quantitatively validate the *technology maintenance* construct, which proposes that as access to information and communication technology peaks, the digital divide is increasingly characterized by the (in)ability to maintain access. Data highlight overlooked nuances in digital access that may inform social disparities and the policies that may mitigate them.

Keywords: digital divide, digital inequality, technology maintenance, education, internet access, social inequality, race

Technology Problems and Student Achievement Gaps: A Validation and Extension of the Technology Maintenance Construct

Access to Internet, computers, and cell phones appears to have reached levels of near saturation in undergraduate populations in the US (Dahlstrom & Bichsel, 2014; Smith, Ranie & Zickuhr, 2011). But, unaccounted for digital inequalities may persist even with equal ownership and use (Hargittai, 2010). For example, low- and middle-income families with Internet access are often ‘underconnected’ due to periodic unpaid monthly bills, slow and broken hardware, and shared access (Rideout & Katz, 2016). Given such findings, we examine how inequalities in the quality and stability of access impact people’s lives and experiences, using a lens of *technology maintenance*.

We consider these phenomena using evidence from surveys and focus groups with US college students. Even in that highly connected population, we found socioeconomic differences in students’ struggles to maintain access to technology. Specifically, ownership and use of both cellphones and laptops were nearly universal, but roughly 20% of respondents experienced problems like broken hardware, data limits, and connectivity problems. Students of lower socio-economic status and students of color disproportionately experienced hardships. Findings reveal a range of connectedness and distinguish three new conceptual stages of technology maintenance: *achieving access*, *sustaining access*, and *coping with disconnection*. Those struggles also had consequences. Our survey and focus group data both revealed a link between the challenges of technology maintenance and students’ academic performance. Our findings are consistent with technology maintenance, a new construct that explicitly explores the stability of digital access (Shoemaker et al., 2004 for construct/concept distinction). The

technology maintenance perspective posits that even as technology ownership and Internet use become pervasive, new digital divides manifest when individuals have difficulty maintaining access (Gonzales, 2014, 2016). Qualitative research suggests negative effects of short-term disruptions on healthcare, employment, and interpersonal social support (Gonzales, 2014, 2016; Gonzales, Ems, & Suri, 2016). This study offers an important, first quantitative validation of this construct. Given the relationship we find between technology maintenance and academic performance, our findings may partially explain previously established socio-economic achievement gaps in college outcomes (Kuh et al. 2008; Pascarella et al. 2004). While our data are not representative of all college students, they highlight the need for more research on technology maintenance and for policies that mitigate technology maintenance-related disparities.

Technology Maintenance: A New Digital Divide

Access to information and communication technologies has expanded dramatically in recent decades. But, how do technology-related inequalities persist, even as technology itself becomes ubiquitous?

Technology maintenance proposes that, as access to information and communication technology peaks, the digital divide will be characterized by inequalities in the ability to maintain access to technology. Gonzales first introduced the construct as the “constant effort required to ensure stable [cellphone] access, even after initial access, defined as in-home or public access, was acquired” (2014, p. 241). Subsequent studies revealed that low-income individuals often rely on a range of computing technologies that are broken, borrowed, or *dependably unstable*, cycling through routine disconnection (Gonzales, 2016; Gonzales et al., 2016). The construct builds on prior research showing

that maintaining access to digital technology requires both financial (e.g., money for monthly service fees) and social resources (e.g., rides to the library, device-sharing) (e.g. DiMaggio, Hargittai, Celeste, & Shafer, 2004; Selwyn, 2004; Robinson, 2014; Robinson & Shulz, 2013; van Dijk, 2005, 2006). Because of those resource requirements, digital inequalities originate from (and contribute to) socio-political inequality *writ large* (Gilbert, 2010; Robinson et al., 2015; Ragnedda & Muschert, 2013; Warschauer, Zheng, Niya, Cotton, & Farkas, 2014). That is, a technology maintenance perspective was proposed to acknowledge and underscore the incremental and ongoing struggle that less-privileged populations experience in their efforts to achieve digital equality.

Theoretically, the construct of technology maintenance is consistent with a *stratification model* of digital adoption (Norris, 2001, van Dijk, 2005), and builds on cultural-critical work on breakdown and repair as a mode of understanding stratification (Graham & Thrift, 2007). Consistent with the *rich-get-richer* effect of media diffusion, digital innovations may exacerbate social inequalities when the privileged exploit and embed digital technology in everyday social functioning (e.g. getting a job, getting good grades; van Dijk, 2005; van Deursen & Helsper, 2015). Similar inequalities have also been found among young people, where research has revealed socioeconomic differences in students' experiences with technology both at home (Robinson & Schultz, 2013) and at school (Robinson, 2014). Technology maintenance is a context non-specific construct that elaborates on these fluid and evolving aspects of digital access.

Technology maintenance is informed by a robust body of digital divide scholarship. One focus of this work has been on *how* people use the Internet. For example, Ragnedda and Muschert (2013) argue that “the biggest concern is not always

concerning access, but the divide among information ‘haves’ and ‘have nots,’ resulting from the ways in which people use the internet” (p.2). Although appreciating differences in skill and content is essential (Hargittai, 2002; Hargittai & Hinnant, 2008; van Deursen & van Dijk, 2014), gradations in the quality and functionality of technology should not be overlooked. For example, less-privileged Internet users are more likely to rely on lower quality technology (e.g. dial-up v. broadband; computer age; mobile v. large screen; location of access; Davison & Cotten, 2003; Hassani, 2006; Mossberger, Tolbert, & Hamilton, 2012; Zillien & Hargittai, 2009). Much of the research on the functionality and quality of technology, however, has been done in less-developed settings (e.g. Horst & Miller, 2006; Ling & Donner, 2009; Ureta, 2008). Such issues are rarely a focal point of research in industrialized context (see Robinson’s work for exception), but they are deeply important. As Van Dijk (2005) notes, “statistics on computer and Internet access are often exaggerated, and real access problems are obscured” (p. 47). Indeed, seminal works have proposed models, typographies, and ‘stages’ of access that incorporate the need for stable, high-quality physical resources (e.g. van Dijk, 2005, 2006; DiMaggio, Hargittai, Celeste, & Shafer, 2004; Selwyn, 2004). The technology maintenance construct builds upon these broader conceptual approaches by fleshing out the experiences and consequences associated with ongoing maintenance specifically.

College Students: A Test Case for Technology Maintenance

American college students are increasingly dependent on information communication technologies (ICTs) for success in school (Kang, 2016; Livingstone & Helsper, 2007; Robinson, 2014). Among young adults, rates of Internet use (97%), social

media use (89%) and cell phone ownership (98%) are extremely high (Pew Research Center, 2016). Internet and cell phone use among college students, and particularly those aged 18-24, is also more common than among non-students of a similar age (57%; Pew Research Center, 2010; McGraw-Hill Education, 2015). Those high rates of use likely reflect the fact that college students regularly use ICTs for school-related purposes (Cerrantani et al. 2016; Cotton & Jelenewicz, 2006).

Access to digital communication technologies is beneficial and even critical for college students. ICTs, for example, enhance interactions with classmates, instructors, and course content (Hamid, Waycott, Kurnia, & Chang, 2015). Although sometimes a distraction (Junco & Cotten, 2012; Lepp, Barkley, & Karpinski, 2013; Samaha & Hawi, 2016), ICTs can foster rich collaboration, lower anxiety among students, and allow instructors to observe student progress (Lee, 2014). And although American college student ICT access is generally high, lingering disparities remain. Prior research has shown that women, minorities, and working-class students are less likely to be online or as successful in navigating the web (Jackson, Zhao, Kolenic, Fitzgerald, Harold, & Von Eye, 2008; Tien & Fun, 2006). Disparities exist at the individual and institutional level (e.g. in historically Black colleges and universities; Hill, 2012), and may exacerbate inequalities in academic achievement.

Inequalities in access to digital technologies are also linked to inequalities in students' experiences generally. Undergraduates report that ICTs promote enhanced communication, convenience, and engagement with peers and instructors (Waycott, Bennett, Kennedy, Dalgarno, & Gray, 2010). And because use is widespread among

college students, those who lack technology may be particularly vulnerable (Hargittai, 2010).

In sum, prior research on college students and technology access suggests that technology ownership and use are near universal. That said, research also shows that lingering disparities in access have real and negative consequences for students. What prior research has not shown, however, is whether there is a lingering digital divide in college students' efforts to maintain access to their technologies. Nor do we know how those technology maintenance efforts are related to larger patterns of inequality in college success as measured by GPA.

Technology Maintenance in College

Despite the lack of research on technology maintenance in college, there is reason to suspect that such inequalities will matter for students. Research on elementary and high school students, for example, finds that moderate- and low-income US families are often "under-connected" due to intermittent disconnection, shared access, and slow or mobile-only in-home service (Rideout & Katz, 2016). Similarly, qualitative work on high school students highlights the complicated coping efforts low-income students undertake to compete academically with better-resourced students (Robinson, 2014). Such findings support a larger body of work linking economic hardship to struggles with academic success (e.g., working multiple jobs compromises time needed for scholastic achievement; Armstrong & Hamilton, 2013; Bozick, 2007; Goldrick-Rab, 2016; Paulsen & St. John, 2002). Despite such evidence, however, it is unclear whether university

students experience inequalities in the quality and functionality of their technology and whether such inequalities are associated with academic achievement at the college level.

Our first goal in this study, then, is to assess the extent to which socioeconomic status is associated not only with inequalities in initial access to digital technologies but also in maintenance struggles. Building on prior qualitative research on technology maintenance, we employ quantitative measures to operationalize three different stages of maintenance: *achieving* access, *sustaining* access, and *coping* with access disruptions. These stages are not discrete or unidirectional. Finally, we did not expect to find systematic socioeconomic differences in software access in this sample because, although software can certainly be expensive, students in our sample all have free access to up-to-date software through Campus Technology Services. Thus, this analysis focuses on issues and inequalities related to hardware and connectivity.¹ With respect to those challenges, our first research question asks:

RQ1: In a sample of US university students, to what extent do some students still experience difficulties in *achieving*, *sustaining*, and *coping with disruptions* in access?

Given prior technology maintenance research, we expect that the digital divide will disproportionately manifest for low-income students. Qualitative and descriptive work supports this position (Gonzales, 2016; Gonzales et al., 2016; Rideout & Katz, 2016; Robinson, 2014), but, to our knowledge, it has not been quantitatively tested in a sample with broad variation in SES. Given prior research, we therefore expect that:

H1: Socio-economic status, as measured by parent education and tuition assistance, will be negatively associated with students' technology maintenance struggles.

Next, we examine the idea that technology maintenance problems might be negatively associated with student outcomes. Previous research has found that elementary and high school students with disjointed access to technology may struggle in school (Rideout & Katz, 2016; Robinson, 2014), but those studies do not directly assess the link between technology problems and educational outcomes. We expect that technology maintenance will be associated with lower grade point averages (GPA) and that it will at least partially explain socioeconomic inequalities in GPA. However, prior research provides insufficient evidence to predict which specific maintenance variables will best predict variation in GPA. Thus, we pose the final research question as an exploratory analysis:

RQ2: How are various measures of technology maintenance associated with GPA and how do those patterns vary with students' socioeconomic status?

Methods

Survey

Participants. We recruited communication and sociology students over three consecutive semesters between 2014-2015. Most students were recruited from a large introductory communication course on social media at a Midwestern university. This introductory communication course enrolled 250-350 students each semester. We also included 65 students from a sociology course. The final sample included 748 students: $n_{comm} = 251$, $n_{sociology} = 32$ (Semester 1); $n_{comm} = 259$ (Semester 2); $n_{comm} = 206$ (Semester 3) (Table 1; see Appendix B available onlineⁱⁱ). We removed duplicates from the sample. Students received course credit or extra credit for participation.

The average enrollment for the university during the time of sampling was 34,859 undergraduates, making the sample roughly 2% of the population.ⁱⁱⁱ White students represented a slightly larger percentage of the sample than the university population (69.4%). Also, because the sample was derived from lower level courses, the data over-represent freshman compared to the university population (18.6%) and underrepresent juniors (23.5%) and seniors (33.1%). This non-probability sample is neither representative of the university population nor of college students nationwide, but it serves to refine the content validity of quantitative technology maintenance questions for use in probability-based surveys, which are sorely lacking.

Measures

Demographic measures. Demographic covariates used in all models include student sex, primary racial/ethnic identity, and grade level (see Table 1). Due to model complexity and to the disproportionate number of Whites and freshmen, we dichotomized all variables. We excluded age from the models due to collinearity with year in school.

Socio-economic indicators. We measured socio-economic status (SES) with two variables: parent education and receipt of tuition assistance from parents (Table 1). Scholars disagree about the best way to operationalize SES (Lareau & Conley, 2008). Following other research on social class and higher education, we opted to use measures that tend to be more accurately reported by students than parent income (Armstrong & Hamilton, 2013; Lewin, 2009). We calculated parent education by averaging mother and father education, each assessed on the same 6-point scale (*1 = no high school diploma/GED, 2 = high school diploma/GED, 3 = associated degree (2-yr college*

degree), 4 = *bachelors degree (4-yr college degree*, 5 = *masters degree (MA, MBA, MB, etc)*, 6 = *doctoral degree (PhD, JD, MD, DMD, etc.)*. We then reduced the averaged item to a three level, categorical independent variable for regression modeling ($1 = \leq$ *Highschool Degree*; 2 = *Some college training – 4yr degree*; 3 = *Some graduate training – PhD*). A second, separate, indicator of SES was receipt of tuition assistance from parents ($0 = none$, $1 = we\ share\ tuition\ costs$, $2 = parents\ pay\ all\ tuition\ costs$). Higher SES students are overrepresented in our sample. Parents of just over half of the students in our sample paid their children’s tuition and nearly three-quarters of those parents had achieved at least some college education (see Table 1). Our results therefore conservatively estimate issues associated with the digital divide, since access to technology is not uniform across these groups.

Technology maintenance variables. We operationalized technology maintenance variables based on previous qualitative findings of technology maintenance phenomena, including periodic disconnection; sharing or lending patterns; and system quality (Gonzales, 2014, 2016; Gonzales et al., 2016; Rideout & Katz, 2016; Robinson, 2014). Because university students vary in financial independence, we also asked who purchased the technology they use. The resulting items include traditional ownership measures and more nuanced measures of achievement, sustainment and coping. We anticipated that lower SES students would: bear more responsibility for achieving access; face more difficulty sustaining access; and have fewer personal resources when coping with disruption. Instead of indexing these items, we individually analyzed them to gauge the scope of previously untested measures of access (see online supplement Appendix A for all items).

Our models include six dichotomous measures of ownership—laptop, desktop, smartphone, flip-phone, tablet, and printer ownership. Our models also include 13 technology maintenance variables. Five of those assess how ownership was *achieved*, including who paid for laptops, cellphones, service plans (and whether those plans are prepaid), and data overage charges. Four of the technology maintenance variables assess students' ability to *sustain* access. We determined laptop and cellphone functionality by averaging two variables: *How well does your laptop/cellphone work?* and *How satisfied are you with the quality of your laptop/cellphone?* (Likert 1-7, $\alpha = .90-.91$). Two other variables note how often students experience temporary disruptions in laptop and cellphone access. Finally, four technology maintenance variables assess *coping* responses. Students reported whether they had ever borrowed technology from a friend or family member when their hardware was broken or lost, and whether they had used campus computers when their laptops were non-functioning. Students also reported their ability to get a loan to fix or replace technology and how long it would take them to replace a non-functional laptop or desktop.

Schoolwork and grades. To assess the relevance of technology maintenance to school success, we asked students how often they used cellphones and computers for schoolwork. We also asked how disrupted access affected their ability to complete coursework on time and whether they had ever requested an extension on an assignment for technology-related reasons. Students also self-reported their grade point average (GPA). We dropped four cases due to non-standard entry (e.g. 0, 308). The remaining cases were normally distributed.

Analytic Approach. To test H1, we examined the relationship between SES and each technology maintenance variable using a series of linear, binary logistic, ordinal logistic and multinomial logistic regression models. For each model, the data supported the hypothesis if changes in the SES variables were associated with changes in a technology maintenance outcome in the expected direction. Each model accounts for demographic covariates of age, race, and year in school. In cases where ordinal models violate assumptions of proportional odds, ordinal variables had to be re-tested using multinomial logistic models. Because multinomial logistic output is very rich, we present results for each model in a separate table (Tables 2-4, 6-9). We collapsed results of the remaining linear, binary logistic, and ordinal logistic models into one table (Table 5). Finally, to test H2, we conducted a series of ordinary least squares linear regression models, each model regressing GPA separately on a technology maintenance predictor variables and demographic and SES covariates (Table 10).

Focus Groups

Participants. We conducted focus groups to qualitatively explore how students' socioeconomic status was related to their experience with technology maintenance on campus. Although we conducted focus groups first in order to refine the quantitative survey, we primarily use these data to contextualize and expand on the survey findings; thus, their analysis follows the survey analysis.

In 2014, we invited students using on-campus flyers and paid participants \$10 for their time. To understand how the challenges of technology maintenance vary with students' access to resources, we had students complete a brief demographic

questionnaire, and we used the results to stratify participants into three focus groups by SES ($n_{\text{High SES}} = 4$; $n_{\text{low SES}} = 9$; $n_{\text{mixed SES}} = 5$).^{iv}

Data collection & Analysis. The authors conducted three focus groups lasting approximately 2 hours each. The authors used a semi-structured discussion guide with questions about technology owned, problems encountered (especially school-related problems), and strategies used in managing those challenges. Students described their experiences with technology and responded to vignettes describing hypothetical students experiencing problems with technology. As prior research has shown (Barter & Renold, 2000; Calarco, 2014), vignettes are a useful interview tool for clarifying differences in how individuals might interpret and respond to similar challenges. The focus group discussions were audio recorded and transcribed by the second author, producing roughly 100 pages of single-spaced transcripts. The second author analyzed the transcripts, with input from the other authors, using both open-ended and focused coding related to technology maintenance (Miles, Huberman, and Saldana 2013). That coding process identified emergent themes and patterns in the data. We then used data matrices (Miles et al. 2013) to compare themes and patterns by SES.

Survey Results

Descriptive findings. Our first aim was to assess whether digital inequalities persist in the context of widespread access to information and communication technologies. Although this sample is not representative, it is important to determine whether and how SES and access measures varied. We first report descriptive

information about ownership. We then describe students' experience of achieving, sustaining, and coping with disruptions in access.

Technology Ownership. Consistent with prior research on the digital connectedness of college students, we found that nearly every student owned a laptop (97.8%) or a smartphone (94%). Over one third of students also owned a flip-phone (36%), tablet (36%), and/or printer (40%); less than a quarter of students owned a desktop. Given their ubiquity in the sample, the remainder of the analysis focuses on technology maintenance specifically as it relates to laptops and cellphones.

Achieving access. Most respondents, 60%, had laptops purchased by someone else, but 11% had shared the cost, 19% had purchased the laptop themselves, and 2% were given a used laptop. Likewise, 58% of respondents had cellphones that were free with a contract or purchased by someone else, but 20% purchased the phone themselves, 10% had shared the cost, and 3% had a used cellphone. Most students did not pay for monthly service (72%), but 11% paid the entire monthly bill and 8% paid for a portion. A larger percentage of students paid some or all data overage-fees (38%). Most students were on a contract plan, but 9% had monthly prepaid plans. These data highlight the fact that ownership is not a homogeneous experience but rather is achieved in different ways that reflect different degrees of responsibility.

Sustaining access. Despite near universal ownership of cell phones and laptops, students varied in how much they struggled to sustain access to those devices. Overall, most students were very pleased (6+ on 1-7 scale) with the functionality of their laptop (68%) and cellphone (62%). However, a substantial minority perceived their laptop (20%) or cellphone (26%) as only moderately functional (4-5.5 ratings), and some

reported poorly functioning (1-3.5 ratings) laptops (8%) and cellphones (7%). For most, laptops and cellphones were dependable (55% laptops, 68% cellphones never broke down), but laptop disruption affected 21% of students once a month or more, and 16% once a year. Cell phones were somewhat more reliable; only 17% reported disruptions once a month or more, and only 10% experienced disruption once a year. These data demonstrate that even a highly connected sample of students experience wide variations in the quality of their technology and frequency with which they experience disruptions.

Coping with disruption. Finally, students employed a range of coping responses when their laptop and cellphone access was disrupted. Roughly half borrowed technology from a friend or family member when personal technology was broken or lost (54%), and 39% had used campus computers. If they had a problem, 73% of respondents believed they could ask someone else for money to fix or replace devices, but 13% were unsure about this option and 8% felt they could not ask others for financial assistance. Nearly 47% of respondents reported that they could replace their computer within a week or less, but 26% said it would take 2-4 weeks, 16% said it would take up to 6 months, and 12% said they would never be able to replace a broken computer.

SES differences in technology maintenance (H1). Given prior research, we predicted that students with lower SES would experience greater technology maintenance problems, even after accounting for other demographic variables (gender, race, year in school) (H1). Indeed, students' technology maintenance was largely (though not universally) influenced by SES (Tables 2-9).

Technology ownership. As expected, our binary logistic regressions revealed no relationship between SES and technology.^v Demographic controls were generally not

associated with device ownership, with the primary exception of printer ownership, which was more common for women ($b = .40$, $S.E. = .17$, $OR = 1.49$, $p = .02$), Whites ($b = -1.16$, $S.E. = .25$, $OR = .31$, $p < .001$), and more senior students ($b = -.63$, $S.E. = .17$, $OR = .53$, $p < .001$).

Achieving access. In contrast, and consistent with our expectations in H1, students from higher SES backgrounds were less responsible for the costs of access (e.g., initial purchase, monthly fees, overage charges) and were more likely to use contract rather than pre-pay plans (Tables 2-5). Students of Color were also more likely to bear the cost of achieving access than Whites.

Sustaining access. Sustaining access was less clearly associated with SES. Laptop functionality was not associated with SES (Tables 5 & 6). Cellphone functionality was positively associated with SES (Table 5), but there were mixed findings between SES and cellphone disconnection (Table 7). Compared to students with more educated parents, students with less educated parents were more likely to experience weekly disruptions, but they were less likely to experience annual disruptions, compared to no disruptions at all. Finally, students of Color had more problems with breakdown and functionality than Whites, whereas females and freshman had fewer problems than males or more senior students.

Coping with disruption. Consistent with our expectations, we found that higher SES students generally had an easier time coping with disruptions. All coping variables were associated with SES (Tables 5, 8-9). Higher SES students were more likely to have borrowed technology from a friend or family when access was disrupted, but were less likely to have used campus computers, which is a less desirable option given their limited

availability. Higher SES students were also more confident they could ask someone for money for technology if needed, and they believed they could replace technology more quickly if needed. Students of Color were more likely to use campus computers and less able to get a loan than Whites; freshman were less likely to rely on campus computers and felt they could replace broken technology faster than seniors. Finally, females felt they could replace technology faster than males.

Technology maintenance problems & grades. A third aim of our study was to explore how technology maintenance inequalities might contribute to inequalities in student achievement. Our data cannot determine causal relationships, but they do allow us to assess how technology maintenance struggles are related to academic success. We found that students were highly dependent on laptops for school work, with 22% using them 1-2 hours a day, 39% 3-4 hours a day, and 42% 5+ hours a day. Cellphones were less critical for schoolwork, with 59% using them <1 hour per day for such purposes; however, some used cell phones 1-2 hours (18%), 3-4 hours (8%), and even 5+ hours (9%) for schoolwork. Half of students (51%) had at some point been unable to complete coursework due to problems with technology, and 36% had asked for an extension due to technology problems. In open-ended responses, one student recalled: “Last semester, I had several final group projects and my hard drive crashed a week before it was due.” Another student commented: “I didn’t have a personal computer for the entire first semester of my freshman year, and because I was not regularly accessing the internet, I didn’t get notification about certain assignments.” These comments illustrate how intermittent disconnection problems affected students academically.

To explore this quantitatively (RQ2), we examined the relationship between each technology maintenance variable and student GPA, using ordinary least squares linear regression models, accounting for demographic predictors for SES, race, year in school, and gender (Table 10). After accounting for controls, none of the technology ownership variables were associated with GPA. However, on average, students with contract cellphone plans had lower GPAs than those without contract plans. Interestingly, students who paid data overage fees themselves had higher GPAs than those students who had others pay for data overage. These models accounted for SES and other demographic covariates. Students who had more poorly functioning laptops and laptops that broke down more often also lower GPAs, even after accounting for SES and other demographic covariates. Finally, coping variables were not associated with GPA, at least after demographic covariates were controlled. Taken together, such findings suggest that technology maintenance struggles may negatively impact student achievement and that they may help to explain SES disparities in GPA. However, they are likely to do so primarily through issues related to sustaining access, and not (at least as much) through issues related to obtaining access or coping with disruptions.

Focus Group Results

Focus group data supplement the survey findings to paint a more nuanced picture of the nature of disruption and its effects on aspects students' experiences in college. Within the focus groups, laptops and tablets were more commonly owned by high-SES participants, but cellphones were nearly ubiquitous. Thus, we focus on cellphones and on the technology maintenance struggles of two specific students: Sam and Jimmy

(pseudonyms). Sam was from a high-SES family; Jimmy was from a low-SES family, and their experiences with technology-related problems were typical of those encountered by other students in the sample. By examining their experiences side-by-side—both were seniors in college, highly motivated, neither particularly tech-savvy—we show how disruptions in smart phone access affected them in school.

Cellphone disparities. Like most high-SES students, Sam owned a laptop and a smart phone, and both were relatively new and problem-free. When Sam cracked the screen on his iPhone, he called his parents right away. As Sam explained:

I mean, they weren't very happy. But luckily I was able to get a new one. I know a lot of people just say "Oh too bad" until you get an update. But they let me get a new one. It just took a couple days. They pay for all my phone stuff.

That broken screen was the worst technology-related problem Sam had experienced in college, and it took only a few days to resolve. It also had almost no impact on his schoolwork, his stress level, or his life more generally. As he explained: *It was [usable], just texting on it was kind of hard to see the screen. And it just didn't look very nice because it was shattered. [laughs].* At that point in the conversation, Sam even went so far as to laugh, as if he recognized that his problem was not particularly consequential.

Jimmy, on the other hand, had numerous ongoing issues with technology. Like other low-SES students, Jimmy could not afford a laptop, and he could not ask his parents for money. He did all his schoolwork on a computer in the library. Jimmy did have a smart phone, which he purchased his freshman year using money borrowed from a friend's parents (money he later paid back using earnings from his job as a waiter). Over time, however, Jimmy's phone became largely unusable. As Jimmy explained:

My smart phone's a piece of crap. It doesn't load things unless I load them 3 or 4 times. I may or may not get certain texts throughout the day. The keyboard doesn't work anymore. The touch screen still works kind of.

Like Sam's phone, Jimmy's phone was broken but still usable. Unlike Sam, however, Jimmy did not try to fix his phone or buy a new one. He simply could not afford to do so, and he was reluctant to ask for another loan. According to recent data, the average cost of a cellphone outside of a contract agreement subsidization was just over \$300 (Hamblen, 2014). Thus, like many low-SES students, Jimmy just tried to make do. As a result, he encountered real challenges. For example, when applying to law school, he almost missed a scheduled phone interview with a law school Dean. As he explained:

In December, I had a phone interview with a dean for law school. And the day that I had it, I was receiving the phone call from him, and my touchscreen was not working at all. So I completely missed his phone call. And that sent my stress level completely through the roof because I really wanted to get in. On the bright side I ended up using a buddy's phone and calling him. I apologized for missing his call, explained why it only took me 20 minutes to find a phone I could use. And I got in, so...

While Jimmy was ultimately able to borrow a friend's phone to make the call, and while he ultimately got into law school, the situation was incredibly stressful, and could have compromised the impression he made. That kind of stress extended beyond school, as well. As Jimmy explained:

My phone's been out at various points. I work part time [as a waiter] and there are plenty of jobs where people have tried to call me to get into work or I've

needed a sub and not been able to call anyone and say “Hey, can you cover for me.” And it’s really been a pain on those days and probably cost me quite a bit of money on shifts I could’ve picked up.

Because of his phone, Jimmy was unable to change his work shift when he needed extra time to study for tests or complete papers. He also was unable to pick up extra shifts that he could have used to help pay his bills and prepare for his future.

As we can see by looking at Sam and Jimmy, while both high-SES and low-SES students experienced problems with technology, high-SES students like Sam tended to experience less severe problems. They relied on their parents for money and, as a result, tended to fix problems quickly. Low-SES students like Jimmy, on the other hand, had problems with each stage of technology maintenance. They relied on older, more problem-prone technology, in part because they could not rely on their parents when theirs became broken or obsolete. Those ongoing technology problems tended to become more severe over time, and they created real challenges, including high levels of stress and problems at work, in relationships, and at school.

Discussion

Access to information and communication technologies has expanded dramatically in recent decades, but technology-related inequalities persist. We examine how SES is associated with students’ ownership of information and communication technologies and with students’ experiences maintaining access to technology. Our study thus builds on prior qualitative research on technology maintenance (Gonzales, 2014, 2016), validating qualitative findings and extending the technology maintenance

construct to the context of education. We proposed three new conceptual stages of technology maintenance: *achieving access*, *sustaining access*, and *coping with disruptions* in access. Although the sample is not representative, the findings reveal that variance in quantitatively operationalized technology maintenance variables exists; that technology maintenance largely (though not universally) varies by SES; and that some aspects of technology maintenance are associated with GPA after accounting for other demographic factors. Focus group data supplement and elaborate on quantitative results and the implications of technology maintenance for students' quality of life.

Our first aim (RQ1) was to assess whether technology maintenance problems exist in an otherwise connected sample. We focused on laptop and cellphone access, as personal ownership of these technologies was nearly ubiquitous. Most students in this sample were given hardware by parents and had monthly service paid for, but 20-40% of students shared some or all those costs. This highlights the fact that achieving digital access is easier for some students. Moreover, approximately 20% of the sample had laptops with limited functionality and cellphones that broke down at least once a month. Disrupted laptop access is especially problematic given that nearly three-quarters of respondents used laptops for schoolwork 3+ hours a day. When problems occurred, nearly half of students borrowed a computer from a friend or used campus computers, but 44% said it would take at least two weeks to replace a device if it failed entirely. These data suggest that about one fifth of students in this sample experienced some complications in maintaining access to laptops and cellphones, despite near universal ownership of those devices.

Another aim was to test whether lower-SES individuals experience more difficulties with technology maintenance (H1). Indeed, achieving and coping variables were consistently associated with SES, supporting H1. SES differences in the ability to sustain access were less clear, with only cellphone functionality showing a relationship to SES. It is possible that the constant use of laptops by young adults leads to breakdown and malfunction, regardless of SES, though additional work is needed to better understand this unexpected null result. Finally, women, freshman, and especially White students had an easier time achieving, sustaining and coping with disrupted access. Again, this is not a representative sample, and thus cannot be assumed to generalize to a broader population. However, these findings help to demonstrate the validity of the *achievement* and *coping* sub-concepts within the technology maintenance construct, and they suggest a need for more representative data on these phenomena.

These results largely speak to previous findings by Robinson (2014) on the technology-related strategies low-income students develop to compete with higher resourced students. Like the students in Robinson's study, the low-SES students in our sample were more responsible for their technology than high-SES students. They were more likely to have to work and save to pay for some or all technology-related costs; they also had less support when technology failed. These expenses, on average, are not minimal when added to the other costs of college attendance.

The final aim of this study was an exploratory analysis of the relationship between technology maintenance and grades (RQ2). After accounting for SES and demographic variables, cellphone plan, responsibility for paying data overage fees, laptop functionality, and laptop disconnection were associated with GPA. It is not surprising that

difficulties sustaining laptop access were negatively related to grades. Most communication with professors, access to course materials, and completion of assignments requires access to a computer; thus, it is possible that laptop disconnection negatively influences grades. It is also possible that being responsible for data charges requires a level of responsibility that may also translate to being academically responsible. In the same way that being responsible for tuition may be associated with academic success in some cases (Arum & Roksa, 2011), students who have to manage technology problems on their own may develop coping skills that support academic success. However, as our focus group data showed, even when low-SES students were ultimately able to overcome technology-related problems, the stress they experienced in doing so still had a substantial and negative impact on their well-being. Thus, future research should look for ways to assess the causal impact of technology maintenance problems on students' success in school and on their more general health and well-being.

Overall, these findings enrich contemporary understanding of digital inequality by elaborating on a new construct. Findings demonstrated that higher-SES students had an easier time accessing technology and coping with disruptions. This association was previously untested, as technology maintenance research to-date has been qualitative, using only low-income samples (Gonzales, 2014, 2016; Gonzales et al., 2016). Our findings also extend the concept of technology maintenance to another realm, education, in which the insidious nature of 'under-connectedness' may be associated with quality of life and social disparities. Ultimately, the data underscore the continued need for a nuanced perspective on digital divides (e.g. Lenhart & Horrigan, 2003; Ragnedda &

Muschert, 2013), even among the “net generation” (Hargittai, 2010; Hargittai, & Hinnant, 2008).

Limitations, Next Steps, and Policy Implications

Our reliance on convenience samples and cross-sectional data mean that we cannot ascertain causal effects of technology maintenance problems on grades; nor can we generalize our findings to a broader population. Representative data is sorely needed on this topic, and lagged diary data or field experiments would help isolate the effects of nuances in access on academic performance. Additional work is also needed to continue refining measures. Our technology maintenance variables were largely categorical, often varying in measurement scale (i.e. nominal, ordinal, continuous). As a result, using variable reduction analysis or path analyses to simplify analyses or create indices would limit the interpretability of the findings. As a first quantification of the technology maintenance construct, we felt it was important to highlight the breadth and nuance of these phenomena by not artificially creating continua or consolidating variables into models that would obscure the import of each individual variable. Indeed, our point is to uncover previously overlooked phenomena. After identifying variables of interest, future work can begin to target variables, making them continuous when appropriate, and thus should pursue a greater range of statistical tests and the establishment of new theoretical boundary conditions. Finally, our focus groups included a small number of participants. Additional qualitative data may be particularly useful for addressing some of these methodological gaps. In particular, a targeted exploration of disconnection in middle- and high-SES populations could help uncover what aspects of disconnection and instability are universal (e.g. Tischleder & Wasserman, 2015) versus socio-economically dependent.

Policy implications. Conceptualizing digital access as a gradient may help to encourage policies that facilitate ongoing support for equal access rather than one-time injections of resources into public schools and community centers (see Makki, O’Neal, Cotten, & Rikard, 2018 for support). One aim of technology maintenance research is to make researchers and policy makers aware of the persistent needs associated with maintaining digital access, even when data may suggest that a population is already connected. Critical to this effort is the continued collection of data on gradients in access. For example, additional on cell phone access and use in a general population is sorely needed. Because the poor are also less likely to own a landline (Blumberg & Luke, 2015), temporary cell phone disconnection and repeated number changes disrupt communication with institutional and personal support networks (Gonzales, 2014; Gonzales et al., 2016). Yet there are virtually no representative data on these phenomena, despite having widespread implications for social inequalities. In addition to new data collection, collaborations between the National Telecommunications and Information Administration (NTIA) and federal health entities, such as the Centers for Disease Control (CDC), could significantly expand our understanding of the link between digital access and individual outcomes. Although hard to obtain, data from corporate entities that provide subsidized access through Lifeline would also fill some of these missing gaps.

Conclusion

Physical access to communications and information technology is becoming increasingly ubiquitous. However, previous digital divide literature points out that owning hardware and getting online are not enough for users to benefit from digital

technology use (e.g., Hargittai, 2002; Norris, 2001; Powell et al., 2010). The technology maintenance construct argues that even those who own laptops and cellphones are not always able to rely on their technology. Digital disparities are often a consequence of bigger problems such as unemployment or illness, but they also contribute to those problems, and will increasingly do so with the rapid digitization of institutional and social infrastructure. Policy solutions that address frequent disconnection are therefore essential as reliance on technology increases and disparities in maintenance continue to grow. Colleges and universities, for example, might do more to support low-SES students in their technology maintenance efforts. At the same time, research suggests that low-SES students are often reluctant to ask for help or accommodations when they encounter problems in school (Calarco, 2014; Jack, 2016). Thus, professors may not always know when students are struggling. Given those challenges, larger, structural solutions—such as allowing students to use financial aid to pay for technology costs—are needed to better reduce these gaps.

References

- Armstrong, E. A., & Hamilton, L. T. (2013). *Paying for the party*. Harvard University Press.
- Arum, R., & Roksa, J. (2011). *Academically adrift: Limited learning on college campuses*. Chicago, IL: University of Chicago Press

- Barter, C., & Renold, E. (2000). 'I want to tell you a story': Exploring the application of vignettes in qualitative research with children and young people. *International Journal of Social Research Methodology*, 3, 307-323.
doi: 10.1080/13645570050178594
- Blumberg, S.J., & Luke, J.V. (2015) Wireless substitution: Early release of estimates from the National Health Interview Survey, July–December 2012. National Center for Health Statistics. Available at:
<http://www.cdc.gov/nchs/data/nhis/earlyrelease/wireless201512.pdf>
- Bozick, R. (2007). Making it through the first year of college: The role of students' economic resources, employment, and living arrangements. *Sociology of Education*, 80, 261-284. doi: 10.1177/003804070708000304
- Calarco, J.M. (2014). Coached for the classroom: Parents' cultural transmission and children's reproduction of educational inequalities. *American Sociological Review*, 79, 1015-1037. doi: 10.1177/0003122414546931
- Dahlstrom, E. & Bichsel, J. (2014, October). *ECAR study of undergraduate students and information technology, 2014*. Retrieved from <http://www.educase.edu/ecar>
- Davison, E., & Cotten, S. (2003). Connection discrepancies: Unmasking further layers of the digital divide. *First Monday*, 8. Retrieved from
<http://www.firstmonday.org/ojs/index.php/fm/article/view/1039>
- DiMaggio, P., Hargittai, E., Celeste, C., & Shafer, S. (2004). Digital inequality: From unequal access to differentiated use. In K. Neckerman (Ed.), *Social inequality* (pp. 355–400). New York, NY: Russell Sage Foundation.
- Gilbert, M. R. (2010). Theorizing digital divides and urban inequalities: Critical

- geographies of 'race', gender, and technological capital. *Information, Communication & Society*, 13, 1000–1018. doi: 10.1080/1369118X.2010.499954
- Goldrick-Rab, S. (2016). *Paying the price: College costs, financial aid, and the betrayal of the American dream*. University of Chicago Press.
- Gonzales, A. L. (2014). Health benefits and barriers to cell phone use in low-income U.S. neighborhoods: Indications of technology maintenance. *Mobile Media & Communication*, 2, 233–248. doi: 10.1177/2050157914530297
- Gonzales, A. L. (2016). The contemporary US digital divide: From initial access to technology maintenance. *Information, Communication & Society*, 19, 234-248. doi: 10.1080/1369118X.2015.1050438
- Gonzales, A. L., Ems, L., & Suri, R. (2016). Cell phone disconnection disrupts access to healthcare and health resources: A technology maintenance perspective. *New Media & Society*, 18, 1422-1438. doi:10.1177/1461444814558670
- Graham, S., & Thrift, N. (2007). Out of order: Understanding repair and maintenance. *Theory, Culture, & Society*, 24, 1–25. doi: 10.1177/0263276407075954
- Hamblen, M. (2014). Smartphone prices are dropping, and will continue to dip through '18. *Computerworld*. Retrieved from <http://ow.ly/ywX33050Gn3>
- Hamid, S., Waycott, J., Kurnia, S., & Chang, S. T. (2015). Understanding students' perceptions of the benefits of online social networking use for teaching and learning. *Internet and Higher Education*, 26, 1-9. doi: 10.1016/j.iheduc.2015.02.004
- Hargittai, E. (2002). Second-level digital divide: Differences in people's online skills. *First Monday*, 7. Retrieved from

- <http://firstmonday.org/ojs/index.php/fm/article/viewArticle/942>
- Hargittai, E. (2010). Digital na(t)ives? Variation in Internet skills and uses among members of the "net generation". *Sociological Inquiry*, 80, 92-113. doi: 10.1111/j.1475-682X.2009.00317.x
- Hargittai, E., & Hinnant, A. (2008). Digital inequality: Differences in young adults' use of the internet. *Communication Research*, 35, 602–621. doi: 10.1177/0093650208321782
- Hassani, S. N. (2006). Locating digital divides at home, work, and everywhere else. *Poetics*, 34, 250-272. doi: 10.1016/j.poetic.2006.05.007
- Hill, R. F. (2012). Still digitally divided? An assessment of historically Black college and university library web sites. *The Journal of Academic Librarianship*, 38, 6-12. doi: 10.1016/j.acalib.2011.11.002
- Horst, H. A., & Miller, D. (2006). *The cell phone: An anthropology of communication*. New York, NY: Berg.
- Howell, D.C. (2002). *Statistical methods for psychology*. 5th ed. Pacific Grove, CA: Thomson Learning.
- Jack, A. A. (2016). (No) harm in asking: Class, acquired cultural capital, and academic engagement at an elite university. *Sociology of Education*, 89, 1-19. doi: 10.1177/0038040715614913
- Jackson, L. A., Zhao, Y., Kolenic, A., Fitzgerald, H. E., Harold, R., & Von Eye, A. (2008). Race, gender, and information technology use: The new digital divide. *CyberPsychology & Behavior*, 11, 437-442. doi: 10.1089/cpb.2007.0157

- Junco, R., & Cotten, S. R. (2012). No A 4 U: The relationship between multitasking and academic performance. *Computers & Education, 59*(2), 505-514. doi: 10.1016/j.compedu.2011.12.023
- Kang, C. (2016, February 22). Bridging a digital divide that leaves schoolchildren behind. *New York Times*. Retrieved from http://www.nytimes.com/2016/02/23/technology/fcc-internet-access-school.html?_r=0
- Kuh, G.D., Cruce, T.M., Shoup, R., Kinzie, J. & Gonyea, R.M. (2008). Unmasking the effects of student engagement on first-year college grades and persistence. *The Journal of Higher Education, 79*, 540-563.
- Lareau, A., & Conley, D. (2008). *Social class: How does it work?* New York, NY: The Russell Sage Foundation.
- Ling, R., & Donner, J. (2009). *Mobile communication*. Malden, MA: Polity.
- Lee, S.-M. (2014). The relationships between higher order thinking skills, cognitive density, and social presence in online learning. *The Internet and Higher Education, 21*, 41-52. doi: 10.1016/j.iheduc.2013.12.002
- Lenhart, A., & Horrigan, J. B. (2003). Re-visualizing the digital divide as a digital spectrum. *IT & Society, 1*, 23–39.
- Lepp, A., Barkley, J. E., & Karpinski, A. C. (2014). The relationship between cell phone use, academic performance, anxiety, and satisfaction with life in college students. *Computers in Human Behavior, 31*, 343-350. doi: 10.1016/j.chb.2013.10.049
- Lewin, R. (2009). *The handbook of practice and research in study abroad: Higher*

- education and the quest for global citizenship*. New York, NY: Routledge.
- Livingstone, S., & Helsper, E. (2007). Gradations in digital inclusion: Children, young people and the digital divide. *New Media & Society*, 9, 671-696. doi: 10.1177/1461444807080335
- Makki, T. W., O'Neal, L. J., Cotten, S. R., & Rikard, R. V. (2018). When first-order barriers are high: A comparison of second-and third-order barriers to classroom computing integration. *Computers & Education*. doi: 10.1016/j.compedu.2018.01.005
- McGraw-Hill Education. (2015, March 9). New McGraw-Hill Education research finds more than 80 percent of students use mobile technology to study. Retrieved from <http://www.prnewswire.com/news-releases/report-new-mcgraw-hill-education-research-finds-more-than-80-percent-of-students-use-mobile-technology-to-study-300047130.html>
- Miles, M.B. Huberman, A.M., & Saldana, J. (2013). *Qualitative Data Analysis: A Methods Sourcebook*. 3rd ed. Thousand Oaks, CA: Sage.
- Mossberger, K., Tolbert, C. J., & Hamilton, A. (2012). Measuring digital citizenship: Mobile access and broadband. *International Journal of Communication*, 6, 2492–2528. doi: 1932-8036/20120005
- Norris, P. (2001). *Digital divide: Civic engagement, information poverty, and the internet worldwide*. New York, NY: Cambridge University Press.
- Pascarella, E., Pierson, C.T., Wolniak, G.C., & Terenzini, P.T. (2004). First generation college students: Additional evidence on college experiences and outcomes. *Journal of Higher Education*, 75, 249-284. doi: 10.1353/jhe.2004.0016

- Paulsen, M.B. & St. John, E.P. (2002). Social class and college costs: Examining the nexus between college choice and persistence. *The Journal of Higher Education, 73*, 189-236.
- Pew Research Center. (2016). [Key indicator demographic highlight report March 15, 2016]. *Pew Research Center Internet Project Survey, January 9-12, 2014*. Retrieved from <http://www.pewinternet.org/data-trend/internet-use/latest-stats/>
- Plitch, A. (2014). The cost of (good) laptops is too damn high! *LAPTOP Magazine*. Retrieved from <http://ow.ly/GR3C3050GuG>
- Powell, A., Bryne, A., Dailey, D. (2010). The essential internet: Digital exclusion in low-income American communities. *Policy & Internet, 2*, 159–190. doi:10.2202/1944-2866.1058
- Ragnedda, M., & Muschert, G. W. (2013). *The digital divide: The internet and social inequality in international perspective*. New York, NY: Routledge.
- Rice, R. E., & Katz, J. E. (2003). Digital divides of the internet and mobile phone. In J. E. Katz (Ed.), *Machines that become us* (pp. 91–104). New Brunswick, NJ: Transaction.
- Rideout, V. J. & Katz, V.S. (2016). *Opportunity for all? Technology and learning in lower-income families*. A report of the Families and Media Project. New York: The Joan Ganz Cooney Center at Sesame Workshop.
- Robinson, L. (2014). Endowed, entrepreneurial, and empowered-strivers: Doing a lot with a lot, doing a lot with a little. *Information, Communication & Society, 17*, 521–536. doi:10.1080/1369118X.2013.770049
- Robinson, L., & Schulz, J. (2013). Net time negotiations within the family. *Information,*

- Communication & Society*, 16(4), 542-560.
- Robinson, L., Cotten, S., Ono, H., Quan-Haase, A., Mesch, G., Chen, W., Schulz, J., Hale, T., & Stern, M. (2015). Digital inclusion and why it matters. *Information, Communication & Society*, 18, 569-582. doi: 10.1080/1369118X.2015.1012532
- Samaha, M., & Hawi, N. S. (2016). Relationships among smartphone addiction, stress, academic performance, and satisfaction with life. *Computers in Human Behavior*, 57, 321-325. doi: 10.1016/j.chb.2015.12.045
- Selwyn, N. (2004). Reconsidering political and popular understandings of the digital divide. *New Media & Society*, 6, 341–362. doi:10.1177/1461444804042519
- Shoemaker, P. J., Tankard Jr, J. W., & Lasorsa, D. L. (2003). *How to build social science theories*. Sage publications.
- Smith, A., Ranie, L., & Zickuhr, K. (2011). College students and technology. *Pew Research Center*. Retrieved from:
<http://www.pewinternet.org/2011/07/19/college-students-and-technology/>
- Tischleder, B.B., & Wasserman, S. (2015). *Cultures of obsolescence: History, materiality, and the digital age*. New York, NY: Palgrave Macmillan.
- Ureta, S. (2008). Mobilizing poverty?: Mobile phone use and everyday spatial mobility among low-income families in Santiago, Chile. *The Information Society*, 24, 83–92. doi:10.1080/01972240701883930
- van Deursen, A. J. A. M., & Helsper, E.J. (2015). The third-level digital divide: Who benefits most from being online? In L. Robinson, S.R. Cotton, J. Schulz, T.M. Hale, & A. Williams (Eds.), *Communication and Information Technologies Annual (Studies in Media and Communications, v.10)* (pp. 29-52). United

Kingdom: Emerald Group Publishing Limited.

- van Deursen, A. J. A. M., & Van Dijk, J. A. G. M. (2014). The digital divide shifts to differences in usage. *New Media & Society, 16*, 507-526. doi: 10.1177/1461444813487959
- van Dijk, J. A. G. M. (2005). *The deepening divide: Inequality in the information society*. Thousand Oaks, CA: Sage.
- van Dijk, J. (2006). Digital divide research, achievements, and shortcomings. *Poetics, 34*, 221–235. doi:10.1016/j.poetic.2006.05.004
- Warschauer, M., Zheng, B., Niiya, M., Cotten, S., & Farkas, G. (2014). Balancing the one-to-one equation: Equity and access in three laptop programs. *Equity & Excellence in Education, 47*(1), 46-62. doi: 10.1080/10665684.2014.866871
- Waycott, J., Bennett, S., Kennedy, G., Dalgarno, B., & Gray, K. (2010). Digital divides? Student and staff perceptions of information and communication technologies. *Computers & Education, 54*, 1202-1211. doi: 10.1016/j.compedu.2009.11.006
- Zillien, N., & Hargittai, E. (2009). Digital distinction: Status-specific types of internet usage. *Social Science Quarterly, 90*, 274–291. doi: 10.1111/j.15406237.2009.00617.x

ⁱ While we do not focus on software issues in this analysis, our qualitative data did reveal that software is sometimes an issue for college students. We found, for example, that not all students were aware of the free access they had to software through the University. That knowledge, however, did not strictly divide along socioeconomic lines. Rather, some of the low-SES students were among the most knowledgeable when it came to free campus technology resources (including software and also laptops and tablets that could be “checked out” of the library for free for short periods of time).

ⁱⁱ All tables appear in Appendix B, available as a supplemental online document located at (insert CR URL when available).

ⁱⁱⁱ Official enrollment reports from the university provided these data. Although the university is a multi-campus institution, only data from the main campus (i.e. the campus of enrollment for all students involved in this study) are reported. Data for total enrollment and demographics were averaged across the three semesters during which the study data were collected (i.e. Spring 2014, Fall 2014, and Spring 2015).

^{iv} Before attending the focus group participants were asked whether parents pay for most or all tuition (yes = 1, no = 0), give the student money every month (yes = 1, no = 0), and what the student's perceived SES was (Low-Income (0), Lower-Middle Income (1), Middle Income (2), Middle-High Income (3) or High Income (4)). Students that scored 3+ were classified as high-SES.

^v Note: the model examining predictors of internet access did not run because of too little variability; nearly everyone had internet access in this sample.