Academic Performance and Mobile Technology Use During the COVID-19 Pandemic: A Comparative Study

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Abstract

Most North American colleges and universities switched to online courses during the COVID-19 pandemic. Therefore, it is important to explore the impact of the newly remote courses on the academic lives of postsecondary students with and without disabilities and on technology use by students. It is also important to ascertain which newly used technologies are likely to be useful in the future. To do this, we surveyed 121 students with disabilities and 51 without disabilities and asked them about their academic performance and about the smartphone and tablet technologies they used to do schoolwork during the pandemic. Results indicate that most students were having a difficult time with learning and studying and that students with disabilities were experiencing more challenges, including the need to drop courses. The most common problems dealt with concentration, motivation, and discipline. The only positive impact reported relates to flexibility and time management. Approximately 70% of students used some form of mobile technology to do schoolwork, primarily Apple devices. The most common technologies reported by students were: Zoom, Google Docs, and Microsoft Word. Overall, most of these worked well, although over one third of both groups indicated that Zoom worked poorly. Where there were differences between the two groups, results show that the technologies were more problematic for students with disabilities. The variety of smartphone and tablet apps used by postsecondary students during the pandemic suggests that now that they have learned to use these, students will continue to use many of these once the pandemic is over.

Keywords: academic performance, smartphone, COVID-19 pandemic, mobile technologies, postsecondary students

Most North American colleges and universities cancelled in-person classes to prevent the propagation of the COVID-19 virus and switched to online courses. It is, therefore, important to explore the impact of such remote online courses on the academic lives of postsecondary students with and without disabilities, to explore their technology use and to ascertain which newly used technologies and practices are likely to be useful in the future. First, technologies that are seen by students as working well could be substituted for those that work poorly. Second, lessons learned during the COVID-19 period could be useful once the pandemic is over. In other words, it is crucial to understand student outcomes and technology use during the pandemic because this can provide the foundation for sustainable practices in the future.

Remote online courses present the following challenges: Many faculty members are just learning to teach online, videoconferencing platforms and course management systems are frequently ill-suited to host such courses, and many students did not voluntarily register for online learning. Although all students are affected by the pandemic, students with disabilities, who may need technical as well as other types of accommodations, are likely to be even more adversely affected. Furthermore, it is important to find out how the pandemic affects the ways in which students use their technologies and how they feel the pandemic

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impacted their academic performance.

How remote learning affects students with disabilities is important because it is estimated that between 10% and 25% of North American postsecondary students have a disability. For example, studies by Fichten et al. (2018) and Snyder et al. (2019) showed that 17% to 19% of the American and Canadian undergraduate population have a disability According to an extensive American study of freshmen enrolled in 184 different universities, 21.9% of students self-reported a disability (Eagan et al., 2017). Also, students with disabilities are more likely to attend two-year colleges rather than universities (McCloy & DeClou, 2013). Indeed, a recent study of two-year Canadian college social science students found that 26% self-reported a disability (Fichten et al., 2019).

There is extensive literature on the use of technology in online learning, as well as on the accessibility of online learning and distance education for students with disabilities (e.g., Almeida, 2020; Chmiliar & Anton, 2017, 2018; Thomson et al., 2015). We also know a great deal about access software that works on Windows and Mac computers (e.g., Fichten et al., 2020). However, these studies do not explore how various mobile technologies are used by students with and without disabilities to complete academic work and to access online platforms in the online remote teaching environment.

We found guidance for K-12 schools (e.g., Reich et al., 2020), conceptual papers (e.g., Williamson et al., 2020), pleas to meet ethical responsibilities to mitigate COVID-19 related risks for individuals with disabilities (Berger et al., 2020), practical tips on how to convert face-to-face classes to remote online learning (e.g., Taylor et al., 2020) and on technical challenges such as connectivity, power outages, assistive devices, technical support and technical training (Dianito et al., 2021; Khumalo et al., 2020; Ro'fah et al., 2020). However, we were able to find only two empirical studies that compared the experiences of postsecondary students with and without disabilities during the COVID-19 pandemic. A study by Zhang and colleagues (2020) showed that students with disabilities were more concerned than their peers without disabilities about classes going online and a large study by Soria et al. (2020) showed more negative outcomes for students with disabilities such as financial hardships during the pandemic due, in part, to increases in spending for technology. They also reported that students with disabilities were less likely to feel like they belonged on campus and that they felt less supported by their school.

All Students Struggle

The government-mandated quarantine and physical distancing measures (Government of Canada, 2020) during the pandemic are associated with mental health and anxiety-related issues (American Psychological Association, 2021; Best, 2020; Statistics Canada, 2021), which were already becoming more prevalent in postsecondary education before the pandemic. For example, a recent study involving 195 students at a large public university in the United States focused on identifying the long-term effects of the pandemic (Son et al., 2020). Results indicate that 71% of the participants reported increased stress and anxiety directly associated with the pandemic, and 82% of students expressed greater concerns about their academic performance. Eighty-six percent of the participants reported a decrease in social interaction due to physical distancing as a stressor. This is in line with findings of Statistics Canada (2020), which noted that participants from a crowdsourcing survey reported that their current health, both mental and overall, was substantially worse than before the pandemic and with a study comparing before and after COVID-19 student redactions to newly online learning (Besser et al., 2020). Numerous studies have documented the negative psychological outcomes of postsecondary students (e.g., Browning et al., 2021; Copeland et al., 2021).

During the beginning of th COVID-19 pandemic, family computers and laptops were less likely to be available to postsecondary students due to stay-at-home orders, which resulted in adults working from home and other children in the family also attending school online (Gillis & Krull, 2020). Issues in the home related to noise and distraction can present additional challenges (Top Hat, 2020). There can also be difficulties with Wi-Fi connectivity (Mupenzi et al., 2020). Given such concerns and possible difficulties with the availability of a computer during the COVID-19 pandemic, it is likely that students have turned to their mobile devices, such as tablets and smartphones. If so, it is important to know what apps and technologies they are using to do academic work during the pandemic.

Uses of Mobile Technologies to do Schoolwork

As early as 2016, Seilhamer et al. (2018) reported that 99% of university students owned a smartphone and 63% a tablet and that they were increasingly using these to do schoolwork. In a recent pilot study, Fichten et al. (2019) investigated the integration of smartphones and tablets into the learning process. The findings show that students with disabilities use their mobile devices for all the same reasons as stu-

dents without disabilities. In addition, students with disabilities use general purpose mobile device built-in features (e.g., font size, speech-to-text, word prediction) and apps as assistive aids. The growth and subsequent reliance on technology brought on by COVID-19 provides a unique opportunity to explore the dual role—general use and assistive technology—that mobile technologies such as smartphones and tablets can play in the learning environment.

Fichten et al.'s (2019) findings show that students, both those with and without disabilities, already use their mobile devices for doing schoolwork outside the classroom. For example, students can access the professor's teaching materials on their devices (e.g., review PowerPoint or Google Slides), listen to audio and video recordings of lectures, access online library services, check the course management system, read e-books, share course notes using WhatsApp email and Facebook messenger, create digital notebooks/e-portfolios, provide visual proof that they had completed an assignment by taking a selfie or making a short video at a designated location, collaborate online to complete assignments, use their device while commuting to start written assignments, participate in course blogs, do online exams, and submit assignments online after these are run through Turnitin plagiarism software.

Uses of Mobile Technologies by Students with Disabilities

Most students experience barriers to their learning due to the pandemic, such as distractions, increased anxiety, and lack of motivation (Gillis & Krull, 2020; Schaffhauser 2020; Tasso et al., 2021). However, the pandemic may especially impede the academic success of students with disabilities, many of whom need accommodations, technical and otherwise, to a greater degree (Romero-Ivanova et al., 2020).

The goal of our study was to ask the students themselves which technologies they used, which of these worked well and poorly for them, how the pandemic affected the ways that students used their technologies and how they felt the pandemic affected their academic performance.

Method

Participants

Participants consisted of 172 college and university students: 121 with disabilities (75 females, 39 males and 7 who indicated a non-binary gender) and 51 without disabilities (32 females, 18 males, 1 who did not indicate). Participants attended 34 different colleges and universities, with 55 students attending a university and 112 attending a junior/community college. As noted in the Procedure section, college students with disabilities are overrepresented in the sample because of the recruitment strategies used.

Among students with disabilities, 88 attended a college and 24 a university; among nondisabled students, 24 attended a college and 23 a university. This difference was significant, as a larger proportion of students with disabilities than without disabilities attended a college rather than a university, $X^2(1, 167) = 7.58$, $p = .01$. College students with disabilities were somewhat older ($M = 22.35$) than college students without disabilities, although this difference was not significant. ($M = 19.96$), $t(109) = 1.80$, $p = .074$. University students with disabilities ($M = 25.03$) were significantly older than students without disabilities ($M = 22.35$), $t(53) = 2.30$, $p = .025$. This is a typical finding (Fleming et al., 2017). The majority of university students were pursuing a Bachelor's degree. Participants were provided with a list of 14 disabilities/impairments and asked to indicate as many as applied to them (see Table 1). It should be noted that 50% of students had multiple disabilities.

Procedure

During August and September of 2020, we administered an accessible online survey (LimeSurvey, version 2) that had been approved by Dawson College's Research Ethics Board. Participant recruitment proceeded in a variety of ways. Email invitations were sent to Canadian postsecondary students with and without disabilities who had participated in our previous research and who had indicated that we may contact them for future studies. Announcements were emailed to discussion lists focusing on Canadian postsecondary education and to project partners (mainly student and campus disability service provider groups). In addition, there were notices put on the websites of groups of students with disabilities. We indicated that we were interested in participants who were currently enrolled in a college or a university. In addition, we also advertised for students at the Canadian college where the ethics certificate was issued. All students were participating in a larger investigation and all received a $25 Amazon gift card. For the present study, students were asked a series of open-ended questions about mobile technologies and apps they used during the spring 2020 academic term when courses were taught remotely.

To ensure accessibility of the LimeSurvey (Version 2), we examined internet-based information on accessibility "fixes," and made sure that we asked questions where respondents had to use only checkboxes, radio buttons, clearly labeled pulldowns, and

Table 1

Disabilities/Impairments of Students

Students' Disability/Impairment	Number of Students
Mental health difficulties / psychological disorder	79
Attention deficit hyperactivity disorder (ADHD)	39
Learning disability (LD)	32
Chronic medical / health problem	22
Neurological disorder	11
Visual impairment (NOT adequately corrected by wearing glasses or contact lenses)	7
Hard of hearing / hearing impairment	7
Speech / communication impairment	6
Limited mobility: use of a cane / crutch / walker	5
Limited use of hands / arms	4
Limited mobility: wheelchair / scooter user	3
Autism spectrum disorder	2
Totally blind	1
Deaf	0

Note. The 121 students indicated 218 different disabilities/impairments. 50% of students have 1 disability; the rest between 2 and 6.

text boxes. We pre-tested the survey with pilot participants who were blind (used Jaws), had low vison (used magnification), learning disabilities (use Kurzweil 3000), attention deficit hyperactivity disorder, and autism spectrum disorder.

Open-ended Survey Questions

The following questions were asked, and large text boxes were provided for students to provide their responses.

1. What smartphone/tablet technologies or apps did you use during the recent academic term (COVID-19 pandemic) to do schoolwork? (a) Which technologies or apps worked well? (b) Which technologies or apps did not work well?
2. How has the current COVID-19 pandemic changed the way you use your smartphone or tablet to do schoolwork?
3. What was the impact of the COVID-19 pandemic on how well you did in your courses?

Categorization of Responses

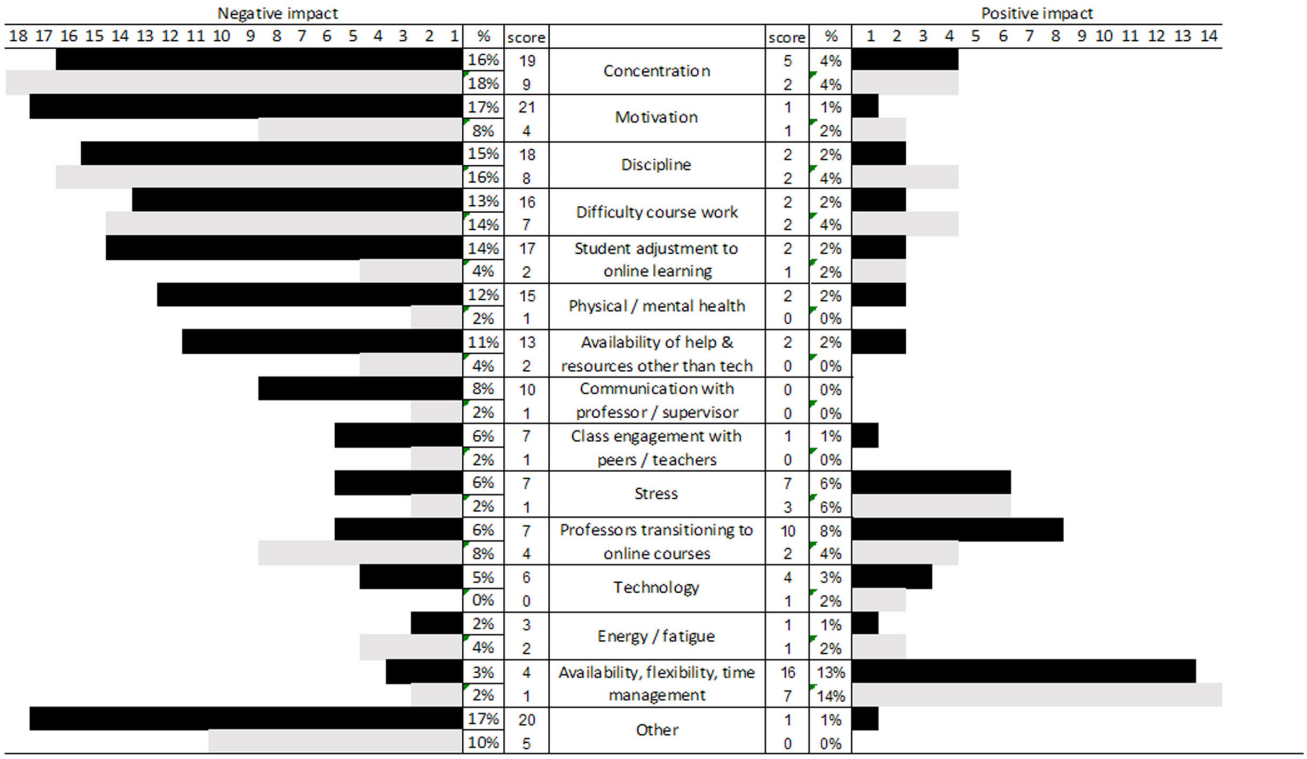
Technologies mentioned by participants in response to Question 1 were grouped into 27 categories by two coders: collaboration, discipline specific, e-books, e-mail, focus, hardware (e.g., smartphone, tablet, convertible 2-in-1 tablet/laptop), internet, messaging and video calls, music and video services, notes, online dictionaries/thesaurus, online storage, organization, other, PDFs, presentation, reading/writing toolkit, reference manager, scanning, speech-to-text, spreadsheet, office suites, time management, translation, university/college portal, videoconferencing, word processing. As seen in Table 4, these were subsequently divided into those that participants indicated worked well for them and those that worked poorly.

Question 2 responses were collapsed into three categories: relied more on mobile technologies, no impact on use of mobile technologies, relied less on mobile technologies. Coding reliability was 97%.

Question 3 responses were examined for impact of the Covid-19 pandemic on grades (improved, no change, deteriorated, and as a separate category: dropped courses). In addition, because students spontaneously wrote about the specifics of the impact of the pandemic we prepared a coding manual (Jorgensen et al., 2020) consisting of 15 categories (see Figure 1). Three coders were trained to a minimum

Figure 1

Impact of COVID-19 on Academic Work



Note. Black bars refer to students with disabilities. The lighter bars refer to students without disabilities. Percentage calculated using 121 for students with disabilities and by 51 for students without disabilities.

70% percentage agreement criterion. Spot checks of 301 codes resulted in an average of 89% reliability.

Results

Question 1

To explore what mobile technologies students with and without disabilities used to do schoolwork during the pandemic, and which of these worked well and worked poorly, we carried out several descriptive frequency analyses. Because there were few participants with several disabilities, it is not possible to provide a breakdown of how well the technologies worked for students with different disabilities.

First, we evaluated what technologies students used. Table 2 shows that between 69% and 74% used some form of mobile technology to do schoolwork. Both groups were considerably more likely to use a smartphone (68% students with disabilities, 61% no disability) than a tablet (27%). Apple phones and tablets were more popular than Android devices for both groups. A few students used Windows tablets, mainly the 2-in-1 convertible hybrids that transform into either a laptop or tablet. Between 20% of students with disabilities and 16% of students without disabilities used both devices.

We explored the frequency of specific, uncategorized technologies mentioned by the students. Those noted by at least five participants are presented in Table 3. The results show that, overall, most of these worked well for both groups of students. However, Zoom worked poorly for over 1/3 of both groups of students. In addition, half of the students with disabilities reported that Microsoft Teams did not work well for them; none of the students without disabilities reported this. As Table 3 shows, common specific technologies were less likely to work well for students with disabilities than for students without disabilities.

As Table 4 shows, the results indicate that most of the 27 technology categories (e.g., collaboration, e-books) worked well for students both with and without disabilities. However, videoconferencing, university/college portals, discipline specific apps, as well as messaging and video call apps posed problems for both groups. Overall, some categories of technologies such as videoconferencing, focus, notes,

Table 2

Mobile Technology Use for Schoolwork

Group	Smartphone			Tablet				Any Mobile Technology
	Use	iPhone	Android	Use	iPad	Android	Other	
Students with a disability								
n	111	65	46	44	31	10	3	121
%	68	40	28	27	19	6	2	74
Students with no disability								
n	45	34	11	20	18	1	1	51
%	61	46	15	27	24	1	1	69

Table 3

Specific Technologies that Worked Well and Poorly During the COVID-19 Pandemic

Technology	Group					
	No Disability			Disability		
	N	Worked Well (%)	Worked Poorly (%)	*N*	Worked Well (%)	Worked Poorly (%)
Zoom	14	64	36	53	66	34
Google Docs	10	100	0	24	96	4
Microsoft Word	3	100	0	29	79	21
Omnivox (Quebec university/college portal)	4	100	0	22	82	18
Calendar (excluding Google Calendar)	4	100	0	15	93	7
Microsoft Teams	6	100	0	8	50	50
Google Drive	5	100	0	7	100	0
Google Calendar	1	100	0	8	100	0
Quizlet	2	50	50	5	80	20
OneNote	0			5	80	20

Note. Worked well and worked poorly reflect the percentage of participants who mentioned the technology.

Table 4

Technology Categories

Category	Technologies	Group					
		No Disability (*n*=51)			Disability (*n*=121)		
		Number	Worked Well (%)	Worked Poorly (%)	Number	Worked Well (%)	Worked Poorly (%)
Videoconferencing	Zoom, Microsoft Teams, Facetime, WebEx, BigBlueButton, Adobe Connect	19	79	26	59	63	39
Word Processing	Microsoft Word, Pages, google docs	15	73	0	51	86	10
Collaboration	Trello, Google Docs, Slack	12	83	0	32	81	3
Hardware	Samsung smartphone, tablet that converts into a laptop, iPhone, iPad, iPad air, iPad pro, Android smartphone, Samsung S9, Samsung a5, Android tablet	8	38	0	35	29	9
University/college portal	studiUM (University of Montreal), portal Ulaval, Omnivox, MyCourses, Moodle, cuLearn (Carleton's Learning Management Software powered by Moodle)	6	83	33	32	72	19
Organization	To Do list, built-in calendar app, Google Calendar, Calendar, Reminders, Apple Calendar, Todoist, Wunderlist, Google task list, myHomework, Reminders on iPhone, Calendrier, Google Agenda, Samsung Calendar, Clock, Tasks, My Exams	8	75	0	25	72	4
Notes	Evernote, Notability, Microsoft OneNote, Good notes, ColorNote, Samsung Notes, Notes	3	100	0	17	88	24
Online dictionaries / thesaurus	Oxford Dictionary, Merriam Webster, Online Dictionary, Online Thesaurus, Linguee	5	100	0	15	80	13
Other	Turnitin, Google Maps, Linguee, Quizlet, WebAssign, MindShift, "swipe" typing, Tide, Bixby, Google Assistant, Perusal, Duolingo, text-to-speech, Dictaphone for iPhone, Voice Dictation, Facebook to communicate with other students, calculator	5	40	40	15	87	0
Internet	Google, Google scholar, Safari, Google Chrome	6	67	0	8	75	0
Reading / writing toolkit	Grammarly, Antidote, Read and Write, Word Q, Spell Check, Kurzweil, Elevate English: Vocabulary, Grammar, and word search, keyboard word prediction	0			12	83	25
Presentation	Keynote (Apple), PowerPoint, Google Slides	3	67	33	9	56	11

(Table 4 Continues)

Discipline Specific	Photomath, Desmos, Wolfram/Alpha, Slader, AutoCAD, SketchUp, Stack Exchange, Webwork, Chegg Study, Solid Edge, Fusion 360, Calculator, MyStudies, Pulse, Eclipse	4	50	257	7	71	43
Messaging and video calls	Messenger, Skype, Hangout, WhatsApp, Discord, Facebook messenger, Facebook to connect	2	50	50	8	88	25
Focus	Stay on Task, Forest, Block Site, Engross, Brain Focus, Focus Keeper, Pomodoro, Pomodoro Timer, Be Focused	1	100	0	8	50	50
Suites	Wps, Office 365, Adobe creative cloud, Microsoft Office Suite	2	100	0	6	67	0
PDF	Xodo, Adobe PDF, Adobe PDF Reader, Adobe software, Microsoft PDF Viewer, PDF Reader	1	100	0	6	67	50
Email	Gmail, courriel, Mail, Microsoft Outlook, Gmail apps	1	100	0	5	100	0
Spreadsheet	Microsoft Excel, Google Spreadsheets, Numbers	2	100	0	4	50	25
Translation	Google translate, Deeply translate	2	100	0	4	75	0
Scanning	CamScanner, Tiny Scanner for mobile scanning of documents, PDF Scanner, Scan It, Microsoft Office Lens	1	100	0	4	50	0
E-books	Kindle app, iBook, Adobe digital editions (to read ebooks I couldn't take out of the library), Pearson e-text	1	100	0	4	100	0
Online storage	Google Drive, WeTransfer, One Drive, Dropbox, MEGA, Files	0			4	50	0
Time management	Interval Timer, Timer, Timer app on my Samsung device	0			2	50	0
Speech-to-text	Voice-to-text, dictation feature in Word, Dragon Naturally Speaking	1	100	0	1	100	0
Music and video services	Spotify, YouTube, Microsoft Stream	1	100	0	1	100	0
Reference manager	Spotify, YouTube, Microsoft Stream	0			2	100	0

Note. "Worked well" + "worked poorly" do not equal 100% because some students who indicated using a technology did not indicate how well it worked and because some indicated that it worked both well and poorly.

and discipline specific technologies worked poorly for a higher percentage of students with disabilities than those without disabilities. In addition, some categories (e.g., reading/writing toolkit, notes) were more likely to be used by students with disabilities than those without disabilities.

Question 2

To evaluate how the pandemic affected the ways students used their technologies we grouped responses into three categories: relied more on mobile technologies, no impact on use of mobile technologies, relied less on mobile technologies. Slightly over 50% of students, both those with and those without disabilities, relied more on mobile technologies and under 10% relied less on these. The rest indicated no change.

Question 3

To evaluate the impact of the pandemic on students' academic performance we conducted two analyses. First, we examined the impact on grades. Results show that approximately 20% of students in both groups felt that their grades improved. Among students without disabilities, 63% indicated no change and 21% indicated that their grades deteriorated. Among students with disabilities the picture was different. Only 34% of these students indicated no change, and 36% indicated that their grades got worse. Nine percent dropped courses.

When evaluating the specifics of the overall impact of the pandemic on their academic lives, students reported primarily negative outcomes. Figure 1 shows specifics about what impacts the pandemic had for both groups of students. The only category where students in both groups indicated a substantial number of positive comments involves the availability and flexibility of time management.

Discussion

Impact of the COVID-19 Pandemic on Students' Academic Performance

Our findings indicate that, consistent with the views of others (e.g., Gillis & Krull, 2020; Schaffhauser 2020; Serhan, 2020; Son et al., 2020), most students have had a difficult time with learning and studying during the COVID-19 pandemic, and that students with disabilities are experiencing more challenges. For example, slightly over 20% of nondisabled students indicated that their grades got worse, but none indicated dropping any courses. As for students with disabilities, 45% reported problems with grades: 36% indicated worse grades and 9% stated that they dropped courses.

Although we did not ask students about the causes of their difficulties, many spontaneously wrote about these. Three quarters of the comments were negative and those of students with and without disabilities did not differ. It should be noted that the most common problems dealt with concentration, motivation, discipline, coursework difficulty, adjusting to remote learning, physical and mental health and obtaining help and resources other than those dealing with technologies. The following quotations are typical of the negative responses:

- "It was easier for me to procrastinate when watching or going to a virtual class than a class in-person."
- "I was very overwhelmed."
- "I found it harder to concentrate because I couldn't go elsewhere to study due to the restrictions."
- "So many deadlines and tests were all clumped together."
- "It was harder to get answers to questions from teachers."
- "It was very hard to transition from in class learning to online, especially with my physics labs. However, after the first month it became easier to adapt."

As noted by others (e.g., Serhan, 2020; Shim & Lee, 2020), the main positive impact reported related to flexibility and time management.

- "I had more time to focus on my studies and work because I had less commute time (saving 3 hours)."
- "I had more time to work on my own schedule."

Smartphone and Tablet Technologies and Apps Used to do Schoolwork During the COVID-19 Pandemic

Approximately 70% of students used some form of mobile technology to do schoolwork. Consistent with the findings of other researchers, both groups of students were more likely to own a smartphone than a tablet and Apple devices were more popular than Android (Seilhamer et al., 2018).

The most common specific technologies reported by students, in descending order of popularity, are: apps related to videoconferencing, word processing, collaboration, and the use of college/university portals. Since both groups accessed their postsecondary institution's portal it is important to ensure that these are not only accessible but that they are also accessible and usable on mobile devices.

Overall, most popular technologies worked well for both groups of students, although over 1/3 of both groups indicated that Zoom worked poorly for them. This is consistent with findings of others, who also found that Zoom had a negative effect on students' learning experience and motivation (Serhan, 2020). Problems with Zoom included dropped signals, frozen screens, audio cutting out, difficulty finding the correct URL, and poor handling of Zoom by faculty who were not well versed in its use.

Where there were differences between the two groups of students, results show that the technologies worked more poorly for students with disabilities. For example, half of the responses of students with disabilities indicated that Microsoft Teams worked poorly for them. This is not surprising given that the literature, both that related to accessibility (Office of Information Technology, 2021) as well as to the functionality of Teams in general (Anderson, 2019) have been heavily criticized. It should be noted, however, that Microsoft has been making improvements (Microsoft Teams Team, 2021).

Fichten et al. (2010) found that students were often expected to employ software for home assignments that their professors had not taught them to use. In the present study too, there appears to be a need for professors to teach students how to use the various technologies associated with their course. This may be especially important for students with disabilities who often need to use these in conjunction with assistive technologies. For example, Microsoft Teams has numerous features and windows, but some of these are not intuitive for students using certain access technologies. It may also be that there are students, including those with learning disabilities, who need to be taught certain skills explicitly rather than relying on them acquiring these through reading instructions or experimentation. As well, high anxiety can prevent students from exploring the use of technology or learning its functions.

The following quotations are typical of students' responses about how they used their smartphone and tablet technologies and apps:

- "I was kind of disorganized during the pandemic and didn't use technologies as I would have wanted to, but I used Microsoft Word, OneNote, and the Timer app on my Samsung device."
- "I used Zoom, but mostly Microsoft Teams to talk with teachers, other students and to hand in homework. I also used Facebook a lot to communicate with other students, and StudiUM (a university/college portal app)."
- "I used Google Calendar for events. I used Word to write assignments. I used Zoom for online classes. I used Omnivox (a university/college portal app) to submit papers."
- "I used the Google Drive app on my tablet. This allowed me to work on my documents and share my documents with my classmates for group projects or presentations, as we were unable to meet in person."

To evaluate how the pandemic affected the extent to which students relied on their mobile technologies we grouped responses into three categories. Slightly over half of the students, both those with and those without disabilities, indicated that they relied more on their mobile technologies during the pandemic than before.

We grouped the specific technologies mentioned by students into 27 categories (e.g., collaboration, e-books). Again, while apps and technologies in most categories worked well for both groups of students, videoconferencing, university/college portals, discipline specific technologies, as well as messaging and video calls posed problems for both groups of students. In general, the apps in some categories worked poorly for a higher percentage of students with disabilities than those without disabilities. Some apps and technologies (e.g., reading/writing toolkit, notes, focus, scanning, ebooks) were more likely to be used by students with disabilities than those without disabilities. This may be because these technologies can at times serve as assistive technologies.

Because there were few participants within certain disability groupings, it is not possible to provide a breakdown of how well each technology worked for students with a specific disability. Yet, the diversity of the disabilities of students who indicated that specific apps worked well or poorly for them support the social model of disability (Barnes, 2007) in that it is not the diagnosis/disability that dictates the suitability of an app; rather it is the interaction of the functional limitation of the student and the task to be performed. Therefore, the same app, for example a text-to-speech app, may be used by students with a wide variety of disabilities, not all of them related to a visual impairment.

Limitations

Our sample consisted of volunteers. Thus, it is neither a random sample nor fully representative of the population studied. Volunteer effects, self-selection biases, and the recruitment methods set limitations on the generalizability of the results. In addition, the number of students with certain dis-

abilities was low. As well, most questions were open-ended. This technique has advantages, such as the ability to collect more detail and to benefit from unexpected insights (Survey Anyplace, n.d.). However, it also has limitations, such as relatively low frequencies of responses and the need for descriptive rather than inferential statistics. While we excluded responses of students who did not indicate that they used either a smartphone or tablet to do schoolwork from most analyses, it is possible that some students' responses reflected using laptops rather than only smartphone or tablet technologies.

Sustainability

Postsecondary faculty are interested in retaining aspects of online teaching once they return to face-to-face instruction (Lombardi, 2021; Top Hat, 2020) and it i clear that online learning has been increasing during the past decade (Allen & Seaman, 2017). Students, too, are likely to continue using some technologies that are popular during the pandemic. Our study brought to light the sustainability potential of certain mobile technologies and apps. The variety of smartphone and tablet apps used by postsecondary students during the pandemic suggests that now that they have learned to use these, they will continue to do so once the pandemic is over. Zoom, the most popular videoconferencing tool of the pandemic (Aiken, 2020; Aratani, 2020) is available on all platforms and devices and free versions can be downloaded without a university license. Students have learned to use Zoom to network among their peers and with their families, so without a doubt, this technology is here to stay.

During the COVID-19 pandemic, certain office suites have become especially popular. Many colleges and universities have provided students free access to Office365 (now called Microsoft 365; Microsoft, n.d.a) and most postsecondary institutions have a license for members of their academic community, making it the de facto university office suite. Google apps are also very popular, largely because these are also free, easy to use, and support collaboration. Both Google and Office365 suites are readily available on mobile devices. Because collaboration features and speech-to-text (i.e., dictation) are available for both Microsoft Word and Google Docs, word processing has become relatively easy even on small smartphones. The same is true for Office365 and Google presentation apps (i.e., PowerPoint and Google Slides). Of course, the larger size of tablets also makes it easy to type. Now that students have learned to use the various features of these office suites, especially the collaboration aspects, we expect these to remain in the future.

Students have also become familiar with free online storage apps such as OneDrive (part of the Office365 suite) and Dropbox. Both are freely available on mobile devices and were frequently mentioned by students in our study. These will probably continue to be used in the future and will result in files no longer being left on a college computer or on a lost USB key when students return to campus.

Using university and college portals is also an important feature of mobile devices. These, of course, give students access to learning resources, including course materials and the library from a distance. They also permit downloading and uploading assignments and collaborating with classmates. Because of the portability of mobile devices, students can check on course related activities any place any time. For example, King et al. (2020) explored the potential of using smartphones by faculty in face-to-face teaching. This feature will likely be used long after the pandemic is over.

Calendars of all sorts were also reported as popular to help students monitor deadlines and to provide reminders. Of course, calendars are a common built-in feature of mobile devices. Because of their portability, smartphones and tablets are especially well suited for this use. Google Calendar, with its collaboration features, is likely to stay with us because of the ease with which groups of students can get together to work on joint projects.

Among the variety of study apps, Quizlet stood out as the most popular. It makes online flashcards and can be used collaboratively. Also, Quizlet has pre-prepared flash cards for popular courses. This makes it perfect for mobile devices and for studying while commuting to the school once in person classes resume.

General Use Technologies as Assistive Aids

Students often do not think of the formidable power of the internet on their mobile device. Yet, Googling provides access to dictionaries, thesauruses, and research and information about most academic subjects (Richards, 2021). The same is true of the ability to dictate (speech-to-text) in mobile email, Word, Google Slides, calendar, and virtually all other apps (Imran, 2021). For example, the latest iPhones and iPads (e.g., iPhone versions 11 and 12) feature a microphone at the bottom of the keyboard, in a large row all by itself.

There is no longer a need to discuss many accessibility features as we all take them for granted (e.g., Apple, n.d.;TELUS, n.d.). Also, mobile apps and built-in features will read information (text-to-speech: e.g., "Siri read my email") (Kargathara et al.,

2021). Similarly, we no longer think of word prediction in our texts or of spelling or grammar checkers in our word processor (Bueno, 2020). Yet these are powerful literacy features and are used as assistive aids by students with different disabilities. Because of these built-in features of mobile devices there is less need for specialized assistive technologies (Kuo et al., 2021). In addition, there are a host of built-in accessibility features in most Apple and Android devices that can be of use to all postsecondary students. These features are described in the Adaptech Research Network free and inexpensive database (http://adaptech.org/downloads/).

Nevertheless, some mobile apps and technologies were more likely to be used by students with disabilities than those without disabilities. This includes reading/writing toolkit apps such as Read&Write and Kurzweil 3000. These are most likely to be useful for students with learning disabilities and other literacy challenges. Organization apps, such as calendars and reminders, as well as those that help students focus (e.g., Forest, Block Site), note taking apps such as Evernote and Notability, scanning apps such as Office Lens and CamScanner, and digital text and ebooks were also more likely to be used by students with disabilities.

Implications of the Findings

While there are many negative outcomes related to the COVID-19 pandemic, some positives have crept in and there are numerous lessons to be learned. Since online learning is an ongoing trend (Allen & Seaman, 2017), the results of the ongoing massive naturalistic experiment that is the pivot to remote learning will inform and change higher education permanently (Gurung et al., 2020; Lombardi, 2021; Kim, 2020; Young & Bruce, 2020;). However, all results of this experiment are not yet in.

Students are often unaware of the potential of assistive technologies for schoolwork

What we can conclude is that students, both those with and without disabilities, can benefit from the powerful apps and features of mobile devices. We can no longer view technology and apps as falling into one of two categories, either mainstream technology or assistive technology. Yes, there are a variety of mobile device features and apps that are intended for individuals with disabilities. For example, there are apps that assist students with low vision, such as screen reading (text-to-speech), scanning and optical character recognition. But there are also what are usually considered general use apps and built-in features of mobile devices that are, in fact, used as assistive aids by students with certain disabilities (e.g., Chmiliar & Anton, 2018; Fichten et al., 2013). One example is the ability to dictate using mobile devices (speech-to-text) that can be used by students with a variety of neuromuscular impairments and some types of learning disabilities. In many cases students who could benefit from the use of mobile technologies are simply not aware that such tools are available. It is likely to be the campus assistive technologist to inform students.

Assistive technologists may need to teach students with disabilities about general use apps

Teaching students about helpful mobile apps that exist and how to effectively use them should be an important aspect of postsecondary education. If faculty do not do this then it will fall upon the assistive technologists who work in access offices to teach students with disabilities how to use mainstream technologies as assistive aids. The literature on accommodations for students with disabilities suggests that currently it is mainly the high-end expensive, multipurpose adaptive technologies that are used when providing accommodations and training (e.g., Malcolm & Roll, 2017). As suggested by McNicholl et al., (2019), "Future AT (assistive technology) practices should focus on harnessing the potential of mainstream devices as AT for all students, thus facilitating inclusion and reducing stigma" (p. 130).

The other major implication of this study is that of sustainability. Much of what postsecondary students have recently learned and integrated about the use of smartphone and tablet features and apps to do schoolwork has been in response to the COVID-19 pandemic and online remote learning. While students with and without disabilities have been enthusiastic users of mobile devices (Fichten et al., 2019), it is mainly during the pandemic that students have been forced to make extensive use of these devices to do schoolwork. It is also during this time that major schoolwork productivity tools (e.g., Microsoft 365 (formerly Office365), Google Docs, Adobe Acrobat) have enhanced their accessibility for both desktop and mobile use (Microsoft, n.d.b); Google, n.d.; Adobe, n.d.). However, it appears that now that students have learned to use these tools, they appreciate their benefits and are likely to continue employing them in the future. Once the pandemic is over and students return to campus and in person instruction, we expect that there will be a "new normal" throughout society. We believe it will touch on all aspects of education, including the use of mobile technology to do schoolwork for all students in postsecondary education, including those with disabilities. What we are

all learning during the pandemic will certainly outlast COVID-19.

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