Emergent Technological Practices of

Middle School Students with Mathematics Learning Disabilities

General Report

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Summer 2020

Funding for this report was provided by

The Saskatchewan Instructional Development Research Unit (SIDRU)

Faculty of Education, University of Regina

Thank you…

to the participants who shared their stories, strategies, and insights.

to the teachers, school administrators, school division personnel, and parents who helped to recruit participants and who made time and space available for these interviews to take place.

to the University of Regina graduate students who have supported and contributed to this work as research assistants: Patrick Nikulak, Lynda-Rae Schmale, Shahed Tameem Aunee and Issah Gyimah. Your ideas and energy were much appreciated.

I am also grateful to the Faculty of Education at the University of Regina for the funding from the Saskatchewan Instructional Development Research Unit that made this project possible.

Table of Contents

Executive summary

Context

Student use of personal electronic devices is growing as technology becomes more available in school and in everyday life. As well, the borders between traditional assistive technology and mainstream technology are becoming more blurred as mainstream technology increasingly adds accessibility features. This study explores the reported experiences of middle years students with mathematics learning disabilities (MLD) who use technology to support their learning.

Approach

This is an exploratory study conducted in four schools located in two urban school districts/divisions in Western Canada. I conducted semi-structured interviews with 14 middle years students who self-identified both as having a mathematics learning disability and as being confident in their use of technology. Six of these participants were female and eight were male. Seven students were in grade 6 and seven students were in grade 8.

Implications

This study has implications for middle years students, their parents and other family members, middle years educators and administrators, as well as researchers. The technology being used by students with MLD is more often mainstream, and mainstream technology itself is becoming more accessible; thus, the foundational implication is that not only can technology help to even the playing field for people with a variety of abilities, but it is also changing the playing field itself to potentially make it more inclusive.

I hope the early findings of the study presented in this report may offer students with learning disabilities confirmation that other students are also using similar strategies, as well as suggest some new ideas for using technology more effectively. It may also provide educators and parents with suggestions about possible technological supports for their students or children. It also reveals that technology is largely being used to assist students with some of the reading and writing involved in doing mathematics but could be used more often to actually explore mathematical concepts.

Results

Depending on their needs, participants in this study reported using technology to access content in various formats, to express their thinking through various representations, and to practice in mathematical procedures and skills.

To access content, participants were making use of various digital texts including printed texts that had been transformed to e-texts, audio (including text-to-speech narrators) and video formats where they were able to adjust settings (e.g. volume, speed) and take advantage of controls (e.g. pause, repeat) to improve their ability to access meaning. Some formats (such as video) offered alternate representations (e.g. visual, dynamic) of concepts that helped their learning. While students frequently used online search engines to conduct research for projects in subject areas such as science and social studies, and had strategies for judging the information they found, participants expressed some reluctance to do the same with math. Participants raised concerns that they would be confused by math information they found online or that it would be cheating (or perceived as such).

Participants found that the structures offered by online notebook platforms, such as OneNote, to be helpful, and they appreciated the availability of cloud-based software offered by the school districts which allowed them to access their files both at school and at home.

To express their ideas and understandings, participants used word processing programs and applications that helped them to revise spelling and grammar, as well as make more effective word choices. They also used slide presentations, videos, games and models as project products.

In math, students reported using calculators and some had used math software, such as IXL and Mathletics, and played online math games in order to practice procedures and math facts. There was no mention of virtual math manipulatives, online graphing calculators, dynamic geometry programs or other applets that might be used to explore and investigate mathematical concepts.

Students who had experience in coding in previous grades or from extracurricular camps, were finding that they could draw on that knowledge for preparing school projects, creating videos, games, models, etc.

The participants tended to follow the guidelines and use the technology approved of by the adults in their lives, and the influence of these adults also informed participants' attitudes towards and uses of technology. Generally, participants reported thinking critically about technology and some were starting to make independent decisions about what applications they were choosing to try.

Conclusions

Although not a panacea, participants reported that using technology helped them work more efficiently, offering some of the support they needed to access content and complete assignments. Students, parents, and teachers are encouraged to continue to explore the accessibility features of mainstream technology, and to consider how they can adapt their day-to-day use of it for more academic purposes.

Context

It has been estimated that anywhere from 3-8% of school-age students in the United States in have mathematics learning disabilities (MLD) (Brennan, 2009; Geary, 2004). It is a complex disability. A number of brain processes feed into doing math, including language processing, visual/spatial awareness, and working memory (Furlong et al., 2015; Willcut et al., 2013). This means that MLD can manifest themselves in a variety of ways, including difficulties with reading math texts, working with numbers, spatial reasoning, problem solving, as well as performing other mathematical tasks. In the classroom, addressing students' mathematical difficulties can be challenging. MLD tend to be diagnosed as students get older, with issues surfacing later due to the twists and turns of the math curriculum and the introduction of new topics in each successive grade (Powell et al., 2013), all of which make early intervention difficult. In a survey conducted for the Learning Disabilities Association of Canada, only 32.8% of parents of children with learning disabilities (LD) reported that their children were doing well or very well in math, compared to 73.7% of parent s of children without LD (Learning Disabilities Association of Canada, 2007). It can take two years of mathematical instruction for these students to progress through a single grade level. Quickly falling behind their peers, students with MLD often leave high school with only a grade 5 or 6 skill level in math (Bouck & Flanagan, 2009) and, unfortunately, these struggles continue beyond their school careers (Powell et al., 2013).

Despite these challenges, 72.6% of students aged 12-15 with LD hope to attend post-secondary institutions (Learning Disabilities Association of Canada, 2007). In recent years, the numbers of students with LD enrolling in post-secondary studies has been increasing (Burton, 2018) and those who have strong help-seeking behaviours in terms of meeting their academic needs (e.g. getting support from the campus accessibility centre) have the same rate of success in their studies as the general population does (Trainin & Swanson, 2005).

Technology has long been touted as a way to support students with disabilities with their schoolwork (Bouck, 2010). Although assistive technology has been available in schools, it has not necessarily been used well used in promoting inclusion in the classroom (Abbott et al., 2011). Where technology is employed for students with LD, it has tended to be assimilated into traditional classroom practices (Olive & Makar, 2010) focused on working with text but using computer screens rather than paper (Kaput, 1992; Meyer & Rose, 2005). Thus, students with learning disabilities could find themselves facing the same kind of difficulties as they would in using a regular textbook. As well, availability and cost have also been an issue (Ochola et al., 2013). In a survey conducted for the Learning Disabilities Association of Canada (2007) 50.3% parents of students with LD reported that their children used aids, special equipment or services, while 29.3% of parents said their children needed these resources but did not have them. For those parents whose children used aids, equipment or services: 59.9% reported that their child used a computer, 11.2% used talking books, 13.3% recording software, and 6.6% used voice activated or voice synthesis computer software. For those parents whose children needed equipment that they did not have: 24.7% needed a computer, 8.9% needed talking books, 14.6%

needed voice activated or voice synthesis computer software, and 5.5% required recording software.

Computer technology, with its flexibility as a teaching tool (Rose & Meyer, 1998), has had the potential to make educational experiences available to a variety of learners. And fortunately, mainstream technologies have been becoming more accessible in recent years. For instance, in a survey commissioned by PopCap (*Survey: "Disabled Gamers" Comprise 20% of Casual Video Games Audience*, 2008), a multi-platform provider of casual games, 20% of its users identified themselves as being "disabled," and of these 11% described themselves as having a learning disability. The developers of the video game *The Last Door* reported that 12% of the first 150,000 gameplays had the closed captioning activated, while 14% used a font specially designed for dyslexics (Garcia, 2013). Recognizing the potential for this kind of use, mainstream technology has been adding features that might have once only been found in traditional assistive technology, such as the "read aloud" and "dictate" features now included in Microsoft and Google offerings. The introduction of these kind of assistive features to mainstream technologies may help users to avoid the issues associated with older forms of traditional assistive technology such as the training time to learn to use it, the cost and the lack of portability (Ochola et al., 2013).

More K-12 students than ever before have regular access to electronic technology, and through this frequent exposure many students have become fluent and confident in their use (Trouche & Drijvers, 2010). In a recent survey of 2,274 American students, 8 -18 years old (Harris Poll, 2015), 83% of students used a laptop for their schoolwork, and 58% used a smartphone and/or a tablet. Of the 760 middle years students (grades 6 -8) who took part in this survey:

- 86% felt tablets help students do better in classes
- 87% agreed that "using tablets in the classroom lets me learn in a way that's best for me"
- 85% preferred the use of digital texts because it meant less to carry on their backs (backpack)
- 92% agreed with the statement that "tablets will change the way students will learn in the future"

Middle school students appeared to be eager to explore the affordances of technology. 72% of those surveyed agreed with the statement "I know more than my teachers about how to use tablets and other computers for learning." 38% of middle years students considered themselves to be early adopters of technology, and 50% reported that they waited to see others try it and then tried it too. Only 12% said they tended to wait a long time before trying new technology. Of those whose schools either provided students with laptops/tablets to work with, or had implemented, a "Bring Your Own Device" (BYOD) policy, 55% of middle years students considered themselves to be early adopters.

In recent years, personal electronic technologies – electronic computer devices which are easily portable and that are used to store, display, process and transmit data (a definition adapted from Ayres et al., 2016) – have become an indispensable part of everyday life, including those who have LD. The home computer was used by 88.3% of Canadian children with LD aged 5-14 years old as a learning support (PALS 2006)[1]. The universality of mainstream devices is appealing; it is natural for students with LD to want to use the same type of personal electronic technology as their peers do (Edyburn, 2013). As Ayres et al. (2016) note, "no one standing in the middle of a store or on the street looks out of place staring at the screen of a smart phone, thus illustrating the social acceptability and validity of the technology" (p. 133).

As more schools turn to BYOD policies (Edyburn, 2013), there is an increased opportunity for personal electronic devices to offer solutions to some of the problems with assistive technology, including cost, portability, and training to use it. Still, mainstream technology has been evolving quickly, and it takes time and exploration before the affordances of new technology are fully recognized and employed creatively and productively. (Edyburn, 2013; Rose & Meyer, 2005). Even the benefits of commonplace technology may go unrecognized (Hitchcock, C, Khalsa, A., Malouf, D.B., Parette, P., Zabala, J.S., & Edyburn, D.L. (2005) study as cited in Bouck, 2010).

My exploratory study responds to a need for more research to determine the effectiveness of new assistive technologies in supporting academic difficulties (Bryant, Bryant, & Ok, 2014), and it privileges the voices of middle school students with MLD, describing what they report about using technology to support their academic studies. The principles of the Universal Design for Learning recommend that students be provided with multiple ways to 1) access information, 2) engage with it and 3) express their understanding about it (Rose & Meyer, 2002), and I will frame my findings through these three principles.

Methods

The study took place from spring 2019 – spring 2020[2] at four urban schools with BYOD policies in two provinces, British Columbia and Saskatchewan. Individual participants took part in semi-structured interviews designed to elicit information about the technology they used to support their learning needs including personal electronic devices (electronic devices designed for personal use such as cell phones, smartphones, tablet devices, and laptop and hybrid computers) and traditional assistive technology (computer hardware and software that has been specifically designed for the use of those with disabilities); how they adapted that use of technology to suit their learning needs; and their opinions about what was effective about their current technology. Permission for this study was granted by the Research Board of Ethics at the University of Regina, and pseudonyms for all participants were used throughout the data collection and analysis.

Middle years students with learning disabilities can be a challenging population for researchers to reach. There is the possible stigma of having a learning disability which students, and their parents, may be reluctant to disclose to a stranger. As well, there is the issue of students taking time away from their studies to participate in an interview. Thus, I very much appreciated the

[1] The definition of learning disabilities in this particular study includes students with "attention problems and hyperactivity."

[2] The last round of interviews was cancelled due to COVID-19.

assistance of the student services teachers and school administrators who recruited the participants for this study by distributing information sheets and consent forms for potential participants to take home for them and their parents/guardians to consider.

I interviewed 14 participants in total, six female and eight male, with seven of the participants being in Grade 6 and seven being in Grade 8[3]. All participants had had been formally diagnosed with a learning disability that affected their learning of math and were on Individualized Education Plans (IEPs), and three had also been identified as being "gifted." In describing their own learning challenges during the interviews, most participants mentioned that they needed extra support with math. A variety of other learning issues were also noted including dyslexia, dysgraphia, difficulties processing language, being easily distracted, and having troubles staying organized. 13 of the students participated in regular math classroom lessons while one worked on an independent adapted program within his classroom.

I used an interview protocol that had been originally developed for a previous study conducted with post-secondary participants with MLD (Armstrong & Gutica, 2020). This protocol was refined for middle years participants based on my own experience as a middle years teacher and suggestions for the wording of questions that were offered by a student services teacher whose school was participating in the study. The interviews featured open-ended questions about how students used their devices and their opinions about them (Swan et al., 2005), ranged in length from 40 – 90 minutes, and took place at each participant's school. Students with learning disabilities sometimes struggle with language processing, which may include verbal expression, so I employed an interview style that privileged doing/demonstrating/gesturing as well as speaking. I listened carefully and reposed questions in various ways if the participant seemed to be interpreting the intent of what I asked differently than I had been anticipating. 12 of the participants brought the electronic devices they used regularly to the interviews so that they were able to demonstrate for me the technology they most frequently and comfortably used. To help to keep the identities of the participants anonymous, details in this report will necessarily be generalized.

As this was an exploratory study, I used grounded theory (Glaser, 1978) to develop categories of the characteristics of the uses and adaptations of technology through recursive data analysis of the video recordings, interview transcripts, my field notes, as well as summary notes from research assistants who listened to the interviews in order to proofread the transcripts. I then used open coding (Corbin & Strauss, 1990) that was grounded in the participants' own words (Li, 2013) and actions. The data was categorized through an iterative process, first involving an independent examination by my research assistants to help foreground different interpretations (Li, 2013), and then a comparison of these interpretations to help me notice features about the

[3] As this was a convenience sample – any student who had MLD, wished to participate and submitted the consent and assent forms was interviewed – the distribution of participants according to gender and grade level was random.

participants' technological practices (Demouy et al., 2016; Kukulska-Hulme & de los Arcos, 2011). In this report, I will describe some trends in the participants' use of technology, including quotes (in italics) from our participants describing what they do.

Findings

As there are many learning issues that may feed into MLD, I wanted to hear from participants about any technology or strategies for using technology that they used to support themselves in their math classes, or performing math in other subject areas, including their ability to access math content and to communicate their mathematical thinking. All participants were allowed the use of electronic devices in their classrooms (with the exception of cellphones – the rules of use varied widely from teacher to teacher), whether this was school equipment such as tablets and laptops that were generally available to all students who needed them, a specific school laptop or tablet that had been designated for a particular participant's use, or their personal devices. Some participants brought the same device back and forth between home and school, while others mentioned using different devices in each location.

During the interviews, some students also referred to technology they used only at home, such as virtual assistants, computers specifically used for gaming, and drones. Some students had their own cellphones while others did not. Surprisingly, only one of the participants mentioned using a traditional assistive technological device (i.e. a device specifically designed for those with disabilities); however, she, like the other participants, mainly relied on mainstream technology and accessibility features offered there.

Outside of their schoolwork, the participants' use of technology varied. Some mainly used it to stream music, and several played video games. A few used it to pursue their own personal projects, such as creative writing, art, and making videos and 3-D models. Some had attended coding camps outside of regular school time. One participant mentioned using facebook, a couple were active on Discord, one participant used Reddit and another streamed his game-playing using Twitch.

Participants felt confident about their use of technology, sometimes acting as a technical resource for peers during group projects or helping out in the classroom.

Basically, yeah I use technology a lot and I think I'm good at using technology. Last year I used to be the person you'd ask if you didn't know how to do something, like people going, ["participant's name!"] in the middle of computer lab time so I'd be running around the computer lab trying to fix everybody's computers for them. Because I was pretty good with that kind of thing.

Overall, participants found technology to be a useful academic support for their learning.

Well, actually, [our school] wasn't actually bring-your-own-device until a couple months after I got my iPad, because they said that I could bring it since I have dyslexia. But definitely I find [using technology at school] a lot easier. It's not stressful [anymore] to worry about, "Oh, I'm *not done this work, I have to go grab this paper," and like, "Oh, shoot, I forgot this," "Oh, this is taking me so long to write it out," and all these things.*

The schools participating in the study used cloud-based software suites such as Google Classroom and Office 365. Participants proved to be very fluent in making use of these during the course of the interviews, but no one commented about them specifically, other than to note that sometimes there could be a lag time in logging on, depending on how busy the school server was, and that they liked being able to log on from home or other locations.

Math class

Participants' initial descriptions of their math classrooms were of a traditional direct-instruction model, with the teacher offering a lesson, worked examples, and then seatwork.

Well I will get the lesson, and after the lesson he'll just give us an assignment and we do the assignment… He'll explain it to us, but we'll have notes to copy down. He'll explain it and we'll have questions to do to make sure we all understand it. And then we get to the assignment.

My lessons? We would usually start off by doing any sort of homework check-up, and we would start doing any math notes that we have to learn about what the lesson is that day. And we would usually be given a handout to do, either there or [at] home, and it would be due next time we see him.

However, with further prompting, participants described doing a variety of activities in their math classes including games and projects.

And for math we're doing a food truck project where we have a license for a food truck and we have to maintain using it like dealing with paying for gas and stuff, buying the pizza ingredients…. we also have to find the floor plan and the surface area for it.

One participant described the recent change in the British Columbia provincial math curriculum and how it had affected activities in math class.

Okay, so in previous years, it's mostly been worksheets, but this year it's been a lot of word problems. Because the way that the curriculum's changed is now, instead of just caring about that we can do the math and that we're doing it the teacher's way, like long division that we have to do with that weird way that's way slower because of reasons. Instead, they care about that we actually understand…. That means that a lot of the math has changed. So, instead of being worksheets or questions, it tends to be a lot of class discussions. So, I'd say about a quarter of math class is a class discussion. Another quarter of it is a lecture or something, and then probably the other half is just worksheets. But the worksheets tend to be word problems and a little longer per question which is fine. I like it more that way, but honestly it doesn't really matter to me.

Still, math class could be frustrating.

Usually we sit down, get in our seats, take out say a textbook, or whatever we need, a sheet of paper, pencil eraser, all our essentials we need. The teacher writes questions on the board, she skims through it, and everyone is following her and I'm sitting there and I'm trying really hard to understand, but nothing's going through my head. That's an issue, right? This is pretty annoying, right? So I try really hard, the teacher walks over and is, "Why aren't you doing your work?" And I'm like, "It's because I don't understand it, maybe?" But, usually most of the time she goes through the work and she's like, "Okay you're on your own now." And I'm like, "Okay." She does a couple questions, tells us "Do your questions." And we're like, "Okay sure." And obviously not all of us understand it right away, so then she walks over or answers a couple questions and all that. So that's usually how it goes.

Most of the participants took part in regular math classes rather being pulled out to do math lessons in a student services room. However, one student described being on an adapted program within his regular class where he used IXL, a website the school subscribed to that offered "personalized learning" for math and language arts skills.

I'm separated from the actual math class. I do IXL. They do other things. There's a few kids in our class that do IXL and I'm one of them. I just sit at the back and do my IXL…. It's kind of the topics that everyone's doing in the class…. It's pretty easy… Then I finish it, and I go to my teacher, and he gives me my new task and then I just do that. I'm basically doing with the class is doing, but just on a lower level.

The level of awareness about the potential of using technology to assist with learning math varied amongst participants, and some did not see much of a connection.

Math is not the subject that we usually use technology in. Because it's hard to, sort of, type in all the numbers and then try to solve that on my computer. It would be easier with a pen and pencil because you could easily write it down, and change anything, and if you need to write a small note on top, it's much easier…. [Do I use it for] math homework? Not really. If [teachers] would take slight exception, even if we're not supposed to, take slight exception of our phone for the calculators only. Only for, really, when we have a practice sheet. And then during tests, if you're allowed a calculator, you need [an actual] calculator. No phone calculator…. Send answers, send answer over to another person, and I'm guessing that's the reason. I've never seen anyone actually take their phone in to a test.

Other participants seemed more aware of using technology to help learn math, but in cases where the participant did not seem at first to recall using technology in math class during the interview, I focused more on asking them how they used technology to help with accessing school content in general, as well as in presenting their work, and engaging with learning.

Accessing content

With increases in technology have come new media which are more malleable to the needs of students (Meyer & Rose, 2002). Digital texts allow for flexibility in how content is represented, be it texts that are on the printed page or on-screen; static images such as photographs, graphs and charts; audio presentations; and dynamic presentations such as animations and videos. Texts can be translated from one format to another (e.g. text-to-speech narrators), and users have control over the presentation of the format (e.g. size, colour, contrast, volume, and speed) to increase their accessibility. The participants reported making use of many of these affordances.

Accessing written text

Some students reported that their teachers made an effort to supply them with electronic versions documents whenever possible.

[My teacher], he'll offer to type it out for me, and most of his stuff is on the computer…. I haven't done it yet this year, but last year, [previous teacher], she found this way that you can take a picture of it and get all the words to put it into a Word document. I'm not exactly sure how you do it anymore because I haven't done it in so long.

For my schoolwork, we don't have enough textbooks, so I use the textbook on my computer a lot. I have it on and scroll it down when I move on to the next question and stuff… I'll read a word and if I don't understand it, I'll look it up on my phone with the dictionary. So, it'll tell me what the word is.

I go to Google Play Books. So, for example, this one. Open series. For examples, if it was this book, I would do this [scrolls through using touch features]. I can zoom it [using touch pad]. I would zoom in, and read, look at the pictures for a minute.

Text-to-speech features, or narrators, were very helpful in supporting the reading of texts. Participants described using the settings to change volume, voice of the narrator, and the speed of play, as well as the ability to pause when needed.

[In] socials and English we would most likely be given this reading in our OneDrive, which we could just use sort of a text-to-speech to read out to us for easier convenience…. We would usually go through it: you can go here [points to screen] to control just how fast you want it, or how slow you want it to read it to you… I find that actually really helpful at times.

I think with the Google Docs one… it does [narrate]. It highlights the word as it goes. I think mine's slowed down a bit, so it's easier for me to go on for the words. You can do that with audio books, speed it up and slow it down. I usually slow it down.

A device that one student reported using was a scanning pen which allowed her to work more easily with texts printed on paper. She described how it works.

Basically, it's a big, bulky pen that highlights. Basically, you take it and go over words on paper [with it] and it'll repeat [them] back to you. You can even get it to change languages or tell you the dictionary definition of the word, so it's pretty helpful.

Participants also described having access to audio books.

I have this app Hoopla where I can listen to whatever book I want to. I get six books a month, and every month it'll discard them and then I can download them again…. It's something for *dyslexia, so they let you do it for free. That's what Hoopla is. It's like a library thing. Yeah. The hard thing is though, the audiobooks that I like to download, they don't really have all of them.*

Both audio and video books offered students greater independence in their reading.

We were given this assignment to read this book called The Outsiders*, so I decided to get an audiobook for convenience. The audiobook was really easy to use because, as it's playing in the background, I can keep track of everything. If I like that quote I can just pause it and write down where it is.*

There was some parts [of our class novel read-aloud] I didn't understand and I couldn't tell the teacher to pause because she was reading it for the whole class. But when I watch a video for [the novel], I can just pause it whenever I want, if I want to see a new word that I want to learn.

Capturing class discussion

Although a few participants reported having some difficulties processing audio information, only one participant mentioned audio-recording lessons delivered by the teacher for later review.

That's often what I will do if there's short lessons. I'll just turn on a voice recording and record it. So then I can go back if, like, if I'm studying for a test and I'd rather just listen to it, because I prefer not to type it out… I don't really do that often. I often delete [the recording] after we're done the test because usually, once I get the test back, I just file [the test] away because then I can just look back at that.

Videos

Teachers sometimes show videos during math class to offer visual and dynamic representations of math concepts and ways to perform mathematical procedures. At times, watching videos in math class could be helpful.

I learned how to do… I can't remember what it was called. There was this thing and it had numbers on it. It was a hill and it had numbers on it and you had to learn how to like ... I want to say percentage but it's like on a ruler how you'd have the numbers and then it goes one two three and then another number and one two three…. Yeah, oh, "number line!" There we go! Yeah, we learned number lines, and there was this really good video that helped me a lot more than that. So, I have had a couple of videos that have helped me.

However, participants noted that simply watching a video in class was not enough in itself.

I mean sometimes [the teacher will] pull up a video on how to explain it, but that like doesn't really do much necessarily. I mean it's a video, right? It's not like someone's listening. You know what I mean? It's something that's been prerecorded and played. It's not an interactive sort of, "Okay, I'm going to explain this to you now," right?

But eventually [in the video] this kid just starts using a compass, like a fake compass, like a technology compass, and he just starts drawing these weird circle things and then he puts numbers on them and tells us to do things. And my teacher expects that I know what to do when [the kid] tells us do this, but [the video] doesn't tell us how.

Despite this potential drawback, some participants reported looking for videos online on their own time to learn more about their personal interests, such as gaming.

Yeah, sometimes there's videos [about using Minecraft] on how to make safe homes so nobody will grief it or anything, take it or blow it up or anything like that or a way to set up traps or something like that or just cool designs or building a house under water, or something like that.

However, only a couple of participants reported looking for videos on their own to build their understanding of math content.

Sometimes I'll have enough background knowledge that I can figure it out and if not, I'll watch a YouTube video on how to do it, or just search it up in Google and just read…. Yeah, I'll look at some videos. We do some videos, like learning stuff, in the class too. Videos help me a lot because I can hear and see… On YouTube, you can slow it down and speed it up so that you can do. I typically just watch YouTube videos… to learn about stuff.

Like with text-to-speech narrators, the ability to control the speed and to stop and start the video was useful. And if one video wasn't helpful, watching other videos might do the trick.

Sometimes the videos can be challenging, and I won't understand it. So, I just watch other videos and sometimes they'd help me, by like drawing pictures and stuff. So, like these kinds of video [pointing at the screen to a video with diagrams and pictures in the video preview area]. Yeah, I understand. When you draw it on a white board, I wouldn't really understand it.

Online research

Despite some participants' use of on-line videos, the idea of using internet resources to supplement math content knowledge was contentious. One participant doubted that he would be able to find the information he needed.

Well I don't think so because the questions we get are on OneNote and the answers to it are in a textbook that the teacher owns. I can't just search it up and find it.

Some felt that online searches for information about math procedures were dishonest.

[If I had a] math question I wasn't sure how to do, I'd go to the teacher and ask them to help me because I don't think I can really search that up. I'll get in trouble for it.

[Google] allows a lot of space for people cheating on things…. So, say they're doing a math question and they figure, "Oh I'll search it up." They search up how to do it, then they'll probably be like, "This is an easy way just to basically cheat."

One participant noted how the potential lack of interaction when using internet content was a detriment.

We aren't supposed to exactly, for math, be going on to a website. Checking how to do it doesn't actually really help you, because if you just look and see how you do it, it doesn't really help. If you're being explained to about how to do it, it's better, because you could get the gist and actually ask questions about the gist. But if a website shows you how to do it, you can't directly *ask that computer to be like, "Hey, but wait, what about this? Can I do that instead?" It doesn't work at all.*

Other participants were concerned that the content of online math sources would be too varied or sophisticated for them to understand and might not match methods being used in class.

Normally I wouldn't really look up things like that, because it's just, it gives you too many different kind of answers. It's a little overwhelming…. When I look [math] up it normally doesn't really give me the exact kind of way that the teacher would show us how to do it. It would give like a different kind of way and I wouldn't understand…. I don't really look up any answers to math, because again, it's just, they overcomplicate everything it feels like.

But if what you're unsure of is the actual formula, I would not suggest actually going on to a computer and looking at it. Going on to a computer and looking for how to do a certain equation isn't really the best choice. You could always get confused with other things. Because asking an actual teacher, or your math teacher is much better because they know exactly it, and the way. Because if you search it up you could accidentally go on to a wrong website and learn the actual wrong way to do it.

In demonstrating how he could look up information on Google, one participant encountered the kind of issues participants had described about researching about math on their own, but also showed a strategy for getting around the difficulties. While performing a lesson on IXL about surface area during the interview, he noted that he did not really understand the formula that IXL was displaying for him to use, in particular the term "Atop plus Abottom" (i.e. the area of the top face plus the area of the bottom face) He turned to Google where a search for "Atop plus Abottom" brought him results for "Top plus Bottom," which included images from a catalogue for women and links to clothing websites. He tried again, typing in "surface area of a cylinder," and this brought him to a different formula that he understood.

In subject areas other than math, participants seemed more aware of the benefits of doing online searches and described strategies they employed. One participant explained how she likes to take the initiative unlike her peers who do not have learning disabilities.

My friends don't use their phones that much and they don't go on Google. They're like, "I don't know this question, I'm going to leave this blank until I know." Where if I don't know this question, I'm going to go on Google and search it up and get the answer!

Another student described strategies in using online searches to find additional information

If I go on to Google Chrome and then I type in "the Greek alphabet"…. Sometimes I'd look up every alphabet. These are pretty helpful [noting the "People Also Ask" feature on Google]. They're a lot of questions with answers about [the topic] and I've used a few of these. I also look up facts that I already know [to see if it would tell me anything else].

One student described how she would work with the definitions she'd been given by Google in order to home in on the meaning she needed.

I would go on Google and I would look it up and I would say "What's the main definition for procrastinating?" or whatever. [If there was more than one answer] I would try to rephrase it. Like if I said, "What does the word procrastinating mean?" and there could be like "lazy," "not doing it," "stubborn." I would be like, "What is another word for lazy?" If it comes up with "procrastinating," then I will be like then it [means] lazy.

One participant noted how some search engines are more effective than others.

A couple months ago like I heard about Google and my friends used it. A couple months ago we had Safari and stuff and we'd go on that. [But] there's a Google option and it's just a lot quicker and it had more answers [than] Safari.

Again, it was important to be critical of what was found during an online search.

[Information you find in a search is] not as reliable because things always change. Technology always changes, everything always becomes different. But it does help at times for other things like how to bookmark a page. It does show here [pointing at screen] how to activate the nighttime mode [for a device]. The nighttime mode is something that you can easily search up because it doesn't really change.

Other resources

To find out more about mathematical content, one participant had found that he could contact "actual math people" online.

Well, I could Google and research stuff and stuff like that. I could consult an expert on it, like I could Discord somebody that works in math. Reddit is a great resource I found. Reddit, you can post something like, "How does this work in math," and stuff and it'll explain it to you really well because there's actual math people who will explain it to you, which is great. Yeah. So, Reddit is actually really great for explaining stuff. I've used it several times to work out harder stuff, and that's what I always tell my friends. They're like, "How do I do the math?" And I'm like, "Go ask Reddit." And, then they're like, "Okay." They go ask Reddit, Reddit explains to them… Reddit is an online newspaper, I would probably call it. It's essentially any ... think of it like a newspaper where anybody can post something and then everybody votes something if you're up or down after they see something. And that lets the algorithm know what you'd like to see as well as know whether that post is good or bad. Whether it's literally nothing or whether it's something that others are going to want to see.

There was a drawback to using Reddit for math help, though.

Reddit would probably do it for me and I'd be like, "Guys, I just wanted you to explain it to me for Christ's sake." They like doing this for you, I'm like, "Reddit, calm down, I just wanted you to explain." They do explain it, but then they also do it. I'm like ... yeah. So, that's usually the last resort, but they do explain it pretty well.

Expressing knowledge and understanding

One of the challenges of a learning disability for students may be the ability to organize and express their ideas and thinking. Technology can help provide ways to structure and store information and files so that they are more easily retrievable; to output information such as through typing, writing or drawing, or speech-to-text; and to automate and produce alternate representations such as video, slides, and graphing. Features like these can help save students time, energy and stress.

OneNote

Several of participants had been introduced to OneNote, a digital version of a physical notebook, within the past school year.

To be honest, it's pretty easy. I just go on OneNote and it has all of my classes on it. Everything is labeled, so I can just press it and I'm ready to go. This language arts [tab] right here, you press it. We scroll down. We see the latest work at the end. Then you're just working on it. It's pretty easy.

I like it a lot because then I don't have to really worry about emailing [work] to [my teacher]. And [One Note] saves automatically, and I'm not going to worry about it deleting because I also have all the questions that I can look at. And it's quite organized, too…. It's exactly like Word, so you can type onto it and everything, and then you can change how it looks and everything. But your teacher can go through if you're messing around with it and change it…. You can share your folders… [For a group project] I could just send it over to them, and they could edit it, and then they could send it back.

In general, students found OneNote to be a helpful way to keep their schoolwork organized.

Well for being organized, my desk, it's not really the cleanest and sometimes I lose pencils and stuff. With OneNote I wouldn't lose anything because it's just all here and I can just try and find it. The only way I'd lose it is if I had deleted it.

I try to remember [my homework assignments] usually, but often times when I get home and I know that I have something to do and a couple things that I have to get done, I'll often just go through OneNote because that's where everything is. And just like go through and be like, "Okay, I have to get that done, that done, that done. I'll just do them all right now."

But not everyone was fully sold on the benefits of OneNote.

All my teachers like using OneNote more than I do really. A lot of the teachers at school like using OneNote because it allows them to hand out things fast. But it's kind of hard to work in sometimes since it's online and that means it's pretty laggy and slow sometimes. [Interviewer asks if he prefers Microsoft Teams over OneNote] Honestly, I don't really like any of them. I prefer that people would just email me assignments and stuff.

FreshGrade

FreshGrade was another system that some schools had been using which offered a gradebook, digital portfolio and communication features that could be shared between teachers, students and parents. Some participants appreciated how it helped to keep their work organized and gave their parents the option of seeing what they were doing.

Well yeah, it's good. My parents don't really see it so much. It's mostly me, but I just kinda like having it just to see what I've done sort of, because... whenever we finish a project, we'd normally put it on there. And then I just like having it. I just like seeing everything that I've done that year.

My mom doesn't use it. My dad uses it to see my ecology vocab quiz. I got ten out of ten, which is the science quiz I just had. He uses it to keep track because I never bring my stuff home so he never knows how I'm actually doing with my project.

However, effective use of FreshGrade depended on whether the users (teachers, parents or students) kept it up-to-date.

Well, we did a lot more with my term one teacher. I haven't really heard [current teacher] saying anything about FreshGrade anymore because my term one teacher, she left at the end of December. So we got a new teacher. And we used FreshGrade for the first week or first few days. But other than that, I mean, I've posted a few things on FreshGrade, but I've never got a response from my teacher or anything.

One participant recommended keeping track of the software settings.

It was really annoying because I forgot to turn the alerts off all the time so I'd wake up at 2:00 a.m. and teachers were still working and it's like, "Really? You had to do that this early in the morning?"

Cellphones

Although not all of the participants had access to cellphones, those who did found them to be helpful for keeping track of deadlines and supplies, by taking a photo of the class whiteboard where assignments were listed, by typing deadline dates into a memo app or by texting them to parents. Students who used their phones as their primary electronic device found it could be tricky for completing assignments.

Because we have laptops at home, but we don't use them that much, we are usually on our phones more. So, I'm like "How do I do this?" I know how to use pen and paper, but I don't know how to use a laptop that well. [Interviewer asks if she could type her assignments on her phone] Sometimes, but my phone isn't connected to the school's printer so I would have to send it to a laptop and print it then.

Participants were very aware of the drawbacks of phones.

Sadly, a lot of people are very sucked into their devices. Which really sucks... No matter where you are, you're going to find someone on their phone. Obviously, it's not the best thing, but it's how we've evolved, so ….

Although school rules about access to cellphone kept changing, varying between classrooms, and sometimes within a single classroom itself if a class had more than one teacher, students seemed to take these shifts in stride.

Managing writing

Participants generally preferred typing their assignments rather than handwriting them because it was neater and quicker.

I always prefer typing because I'm faster at it. Paper, I honestly just don't like writing on paper and handing it in. Most of the time they can't even understand my writing. I've been using my laptop most of the time. It's just more organized and [I am] able to read when I do it online. It's just easier.

Yeah, I don't like handwriting. It's slow and it hurts your hand and I just don't like it.

One participant felt that playing video games had strengthened his hand and finger muscles over time.

Yeah, typing's easier for me and I don't shake as much because I'm used to W A S D [noting the keyboard position of those particular keys]. Because that's from playing a lot of Roblox I've adjusted to this [showing the position] and my hands can go like this for a long period of time.

While some participants used Microsoft Word, others prefered Pages.

I actually just use Word and stuff, but I prefer to use Pages because it's a bit more organized for me. In Pages, you can open up a new folder and when you get a new page, you have choices of a setup that you can get, so it saves me a bit of time when I'm actually working on what it looks like. And it has all these different things you can choose from, which I find it's a bit more helpful so I'm not spending so much time, and I can just get it done a bit quicker.

One participant mentioned the complicated process of using her phone as a writing device.

I would use either like a typing app, but sometimes I just go into, like, I don't think I have it on this phone. It would go in this Pages type of thing. Like sometimes I would go on Safari and type "blank paper" and it would be something like this [shows blank document]. I'll just edit it and just type into it… And then I would kind of paste it on somewhere and I would go to here and send it and then I'd click on it and start typing.

One participant was able to use an app, Snapseed, on her iPad to take a photo of the assigned text page (in this case, a worksheet) and then write, type and draw on the photo.

So, I'll usually use my iPad and take a picture of the worksheet on an app I have and type it out through there. I use this app. When we were doing math this morning, so we did the lesson. So basically, I can type on it whenever I want to, and I can make the size different. And the highlight is just there so I can see it easier when I'm actually doing it, but if I print it out or email it, the highlights don't show up. And you can also draw into it, so it makes it a lot easier… You can type as much as you want. Can type on it... And then just go through and do whatever you want. And then you can really do whatever you want. You can also draw in, too, and you can change *the color of the highlight, too, if you find it easier. And you can draw really whatever you want on it.*

And one participant had discovered a way to type on her device with the keyboard in one room and her screen in the other.

[Our family's old iPad] had this black case and the bottom was magnetic so I can just stick this piece and I just had to hook it up through Bluetooth and then I could type. But the cool part about it was I didn't have to be in the same room as the iPad to type. You just trusted that [the typing] was coming up. So, I used to do that all the time. It would drive my mom nuts.

One participant described how she used the features in the word processing software to improve the readability of her assignments.

I'll change the font size to separate different points and stuff because it's easier to find for me. And if we're answering a question, so it's like [the teacher] wrote all the questions and we just have to fill it in, people will just type with the black colour but I change it so it'll be like red or something, a noticeable colour, that I can still read. So that I know that's my answer. It just separates [what I wrote from the] question so that it's easier for me to see.

While students used standard word processing software features, such as spellcheck to revise their work, they also relied on other resources.

There's spellcheck. But I use Grammarly. I just grab everything, I put it in Grammarly and it checks it for me. That's what I do…. If I get a new document on Grammarly, if I type a full paragraph, it'll just dead on correct the full thing for me. You can right click it and it gives me the main words. Then it does that for the whole paragraph. Then, for every single word, it would just change and it would let me know different options. I could choose a word too. That's basically what I use for my grammar. It's definitely helpful.

With Google Read and Write there's different options. So, it can read what you wrote back to you and then you can also speak into it. There is also a little picture dictionary thing so that if you don't get a word it'll show you a picture of it. I use spellcheck a lot because I can't really spell words that good so that helps me…

Others noted that online dictionary and thesauruses also offered helpful videos about how to define and pronounce words. As well, it was convenient to have an online dictionary or thesaurus open on one browser tab and their writing document on another so that "it's all compiled on one screen" and they easily could toggle back and forth between what they were writing and the dictionary/thesaurus resource.

Speech-to-text

A couple of participants mentioned finding the speech-to-text feature in their word processing software to be helpful.

Yeah, I will use that, depending on if I'm rushing to get it done. Because the typing doesn't usually bother me. But sometimes it will kind of get at me, so then I will talk or dictate it.

However, no one was very excited about digital assistants such as Siri or Alexa.

It's not as reliable. You say something then it mishears you. Then you're brought to a random website and you've got to figure out where you are and [how to] just get back out. But I [would rather] just type it out, or even search it up in a book.

Engagement with content

Effective strategic use of technology in teaching and learning math enables teachers and students to use digital tools in "thoughtfully designed ways" to "enhance how students educators learn, experience, communicate and do math" (NCTM, 2015). This has the potential to let students off-load routine tasks, such as repetitive calculations, allowing them to focus on understanding mathematical concepts (Kaput, 1992); provide immediate feedback; offer dynamic tools that enable students to perform interactive tasks; and encourage the presentation of mathematical concepts using a variety of formats (Suh et al., 2008). For reasons such as these, technology has been recommended for teaching math to students with LD (Bouck & Flanagan, 2009). In their interviews, participants reported using math learning systems such as math education tutorial-style software and online math games, but did not mention using virtual manipulatives (e.g. Illuminations), math applications (e.g. GeoGebra), online graphing calculators (e.g. Desmos), or other online math resources that have been become more widespread in recent years. This does not necessarily mean that these kinds of resources were not being used in these classrooms, just that these participants did not report about them.

Calculators

Almost all participants mentioned calculators. Some mentioned using whichever form of calculator happened to be handy, be it a handheld calculator or a calculator app on their electronic device. Others had a preference, for instance liking to use the one on their electronic device because it was easier to access on screen while they were working on an online program like IXL, and because it also meant not having to carry a handheld calculator around. Regardless of the form of calculator, a couple of students reported sometimes having trouble with the settings.

Most of the time I would use my phone, but sometimes [the calculator on] my phone isn't 100 percent [correct], so I either ask the teacher if I could borrow a calculator or I would try to work it out myself.

Don't use real calculators, they don't work. They don't tell you the right answer ever, they're really annoying. Yeah, that's all I have to say. The [standard] calculators, they don't give you the right answer. They give you the high school answer, or the fake answer. They don't give you the basic answer, [whereas] your phones do unless you set them higher in your settings to do a higher level of math.

One participant was concerned about the possible effects of using calculators in general.

A calculator is good [for checking if an answer is correct], but the teacher's the best option for this because they can tell you if it's right or wrong without telling you the actual right answer. Because calculator would show you, "Oh, it's wrong, but here's the actual right answer." And then… you'd lose the motivation to actually try to find out what you did wrong because you were just shown the actual right answer.

Spreadsheet software

Only one participant mentioned using a spreadsheet program, and he had employed its features in an innovative way.

*Yeah, so I just highlighted all of this [*pointing to screen*] and told [the Excel program] to shade color based on how high the number was. So, higher numbers are lighter colored. Five million is green, while 8e to plus 06 is a lot bigger so it's blue, but zero is just red. It changes depending on the color.*

This participant had also used Excel for projects in other classes.

*I use Excel for all my math stuff because Excel is awesome for science and stuff too. It just lets you do a lot of graphs and stuff, which is great, to extrapolate patterns and record all the numbers and stuff…. Okay, so this was actually a [Health and Career Education] project I believe. But we had to work out financial stuff. So, [*pointing to screen*] here's a bunch of things and how much they cost to hourly, daily, monthly, yearly, and over a lifetime. I mostly just use monthly for my calculations. And, then here's how much money I've had after certain amounts, one-time things I'd have to buy.*

Online math education software

Two online math programs were mentioned during the interviews, IXL and Mathletics, but only IXL was discussed in any detail. Participants reported using IXL in various ways in their math classrooms. One participant's math class used it regularly to supplement textbook work and he found it to be a helpful resource if he wanted to know about a specific topic.

On IXL, it helps you in math and English. I can just search up "surface area" and it'd give me multiple questions about it.

Another participant described having used it in the past for extra practice, although he found aspects of it frustrating.

I don't really use it anymore because, I don't know, I just don't really like it that much. It's okay, but you have to be super specific. Because you have to type in the answer, and if it's not the exact answer they won't register it as right. [Interview: Was it helpful for learning math?] Um, sometimes. I mean, it felt like it was helping me like slowly. Not all at once. Well, I guess that's how most things happen.

As mentioned earlier, IXL comprised the entire adapted math program for one participant who was in grade 8. He explained how it worked.

It comes up on your screen what you did wrong, and it gives you an explanation on what you did wrong and how it could be changed. It actually tells you how to get it correctly…. Once in a while, after I'm done my math, I go onto diagnostic. Then I usually come in [the student service teacher's] room and do my diagnostic, then show her my level. Then I might go to a higher level or a lower level… [Interviewer: Is it helping?] Yeah. It is definitely doing something. I think it would be better if I was actually in the actual class. It's whatever…. IXL is pretty easy for my grade. I'm doing grade seven. I'm halfway done with grade seven. I'm almost at [grade] eight. It's pretty easy for me.

Online math games

Some participants reported being able to play online math games at school after they had finished their regular lessons and most of these games involved practicing math skills.

[Participant demonstrates Sumdog as he speaks] It's pretty much any type of math. [Interviewer: Is it helpful to use to learn math?] Yes and no. Like, the math is helpful. And the games are usually fun. But some of the games, they sometimes keep updating the games, but some people like the older games and the newer games have glitches and things like that. So I personally like the older versions of the games, but sometimes they keep lagging and glitching and things like that.

This is a fake thing, Cool Math games… some of them are actually not actual math games, and then most of them are like thinking games and some of them are just, like this one, not. This one is like a motocross game. You press forwards, jump to jump. That's not a math game, but some of them are like thinking games. Like mostly all of these ones down here [pointing at screen] like that one, and that one. And some of them, I think you can even change the [settings] for it, so it's like numbers, and then it'll do like cool math games that are actually math games.

One participant described how an online math game helped her to learn about percent.

I think that's why I'm pretty good at clicking and stuff, how I get percentages. But yeah [the pet game] did help me. There were other games we played for awhile, like math bingo. This other game, I don't know what it's called, but you had to drive this ship through the numbers or whatever and they'd give you questions. They'd be like "What's ten plus ten?" and then you had to drive into the answer. [The pirate ship game] was mainly appealing to the boys, so they did it a lot. I mainly played the pet game because I always loved animals.

A couple of participants also mentioned playing math games, or math-related games, at home.

[The game] would just ask me questions on it and I'd just write it down and then they'd tell me if it was correct or not…. There was one where I would do it every day and if I finished every day for the week it would say, "You get a prize!" Then my mom would take us somewhere… I think it did [help] a little bit but since I didn't keep going I can't really tell.

I'm not sure Factorio is a lot of math. Factorio would be problem solving, I guess. But it's hard problem solving. Usually Factorio looks like ... if I open it up, it's going to take a while to load.

I'll play the game-play trailer [instead]…[Launches trailer] Anyway, your end goal is to launch a rocket into space and have to turn products into other products. So, yeah, Factorio is just a problem-solving game I play a lot. But I don't really use that for math. I don't really play that many math-based games. I guess you [could] consider Hearthstone math-based because it's numbers, but ... honestly I play Hearthstone because it's fun. But Hearthstone is like a basic video-game/boardgame kind of thing. You know, you have numbers for health and attack.

Coding

Some participants had attended extracurricular computer or coding camps or had learned coding in previous grades at school.

Three years ago, I used to go to a coding class and that's the [Scratch] website we would use. And then so I came back to it a couple years later, like a year later, and then I was like, this was really good for making projects! So I made a bunch of projects and games. I made the games in my own time. Some of them were [things] that I had to [do] with school. I made one where it was like this animation [where] you were in like a digestive system.

[Interviewer: Do you ever use Minecraft for school?] Not exactly Minecraft, but something based around Minecraft. I used to do a lot of coding in my old school. And not just on computer, even though it was on a computer. I did computer and real-life coding. And for the Minecraft thing, it wasn't exactly Minecraft; but it would be Minecraft scenery. There would be a house, and a river. And you would be a Minecraft character, like Steve or Alex, and then you would try to collect blocks or something.

During his interview, one participant demonstrated a quiz he had created for French class using Scratch.

It's basically just coding. So, these are all the different blocks. So, you have things like, the image will move like ten kinds of pixels. You can make it turn. There's things about looking. It can say words. There's more advanced things like this [pointing at screen] and variables and blocks. This is, so, when you would start it would wait a couple seconds and then it would say things like this... It's really bad but it works. So, you click the "begin." And then it will say, "Aha! My name is Poorly Edited French Guy." And then you would type in your answers so, it would say – I don't know, say my name was Bob. [Types in Bob] "Hello Bob." It would take that and then make it as your name.

If you want to use a 3D model software and like Blender, but you don't feel like you'll be using it more in the future, I suggest Minecraft as an alternative to a 3D modeling software. It works fine. It takes longer to build larger objects and it's harder to do details, because you're limited to everything being the same scale for a block, but it's honestly fine for making most things. Like I've done lit[erature] projects, or literary projects, where I've just made houses from the book in Minecraft. I've done projects where I've essentially coded in Minecraft using command blocks. It's fine for anything fairly simple, if you want to 3D model something. Like, me and my friends did a socials project together, right? And we were planning on using Blender, but then they saw how complicated it was and they couldn't use it, so we used Minecraft instead, and we built *ancient Egypt in Minecraft. Took us, what, three months? But we built a giant Egyptian city, three pyramids, which were the pyramids of Giza, right? They were in a line, some stuff, we built the river. What's the river? I forget its name…. We built the Library of Alexandria.*

Only one participant mentioned using coding for a math project.

[For] math projects, I think I've used Unity before. I've coded stuff, like I coded a simple game that would generate a triangle, and you'd have to find the sides of it and do the Pythagorean theorem and stuff.

This participant's awareness varied about how coding might be connected to math.

Programming isn't as mathematical as I originally thought it was. Like, clearly, there is some sort of math. It tends to be more logic based. Because at the very base, it is ones and zeros, so it is math, but when I'm using Unity, it's turning those ones and zeros into, not code, but an actual 3D space. So, I don't actually work with code when I'm doing Unity. I do work with code when I'm programming things like object behavior and stuff in Unity. But I'm pretty bad at that so I don't do much coding. [Interviewer: What about 3D space as mathematical?] Fair enough. Like, coordinates and stuff in Unity, you do have to know ... I do need to know Pythagorean theorem stuff and I use that.

Still, the idea of applying math for a specific purpose had some appeal for him.

But, honestly, I'm fine with math if I'm using it in Unity, but as soon as it just becomes, "Multiply these two numbers because I want you to multiply them," I'm just like, "Okay," [but] don't really enjoy it. But, with working with Unity, it tends to be a small amount of math and a lot of shooting cubes at each other at a thousand miles or per hour which is lots of fun. So, yeah, I just don't really like math, but I'm not too terrible at it that I hate it or anything. I know a lot of kids in my classroom really hate math.

Animation

Participants also applied their outside knowledge of animation and making movies to their classwork. One participant had worked with a partner to create a video for a science project, with him doing the animation and his friend doing the voiceover.

The voiceover actually took longer than doing the animation itself, which was surprising because we had to keep redoing it because it sounded a little bit weird. It still does sound a little bit weird, but… Yeah, we were trying to sound all professional and stuff. The animation itself took about, like, three or maybe four classes. I used an app called, here [finds it], it was called Stop Motion Studio. And you can just get it on your phone. It's super easy. And, so, every time, you just like take a bunch of pictures and then it plays them like superfast. And then it looks like it's being animated. So, these are all, so each of these, each of these frames is like one picture. I drew out every one of these frames, so it would look like it's like animated. And then it goes through superfast and it looks like this [plays clip].

Use of technology compared to peers

When asked how their use of technology compared to that of their peers who did not have LD, a couple of participants noted that they tended to choose a larger font size than their peers did to make texts easier to read. Others used technology to help in different ways ways.

[T]hat's actually kind of a tough question. Me, I probably use more of the text-to-speech more often than anyone else, really, at times…. Yeah, that's pretty much it.

I find that if I have music, and I'm doing my work in my classroom, it gives me something to focus on. But I focus on the music, so I'm listening and I can do my work, like, focus. But if I don't have music like in the classroom, there is so much different conversations going on that I just try to listen to each and every single one and won't focus on my work. It's like having that one audio helps me.

Most participants felt that they did not use technology any differently.

I normally use the same things everybody else does Word, PowerPoint, those are the two things I use the most…. I probably know how to do more things on it than other people do.

Overall, there was a sense that none of the participants felt that their use of technology in class made them stand out.

Everyone's using their laptops in class, just not the same programs.

How participants learned to support themselves with technology

For the most part, participants imitated those around them, whether this meant following the directions or suggestions of a teacher, following family routines around technology, or wanting to use what family, classmates and friends were using.

Influence of teachers

One of the participants recalled how he learned to use Microsoft Word at school:

When I was in elementary school, my grade four teacher showed me, or showed the whole class. He set it up, projected on the whiteboard and he showed us there's this auto save button, you can press that. Or if you don't use auto save, there is save here. And you can choose the font. You can choose the size, underline and centering, and bullets, and all that. And then you just press here, and then you can start typing.

Because OneNote had been introduced in classrooms quite recently, participants were able to recall for me how they learned to use it through demonstrations and support from their teachers. One participant remembered how his class and teacher learned about the platform together.

The [other] technology [I use] I sort of just learned [it] over years and stuff, so it just sort of came naturally. OneNote was actually kind of different. Everyone in the class was introduced to OneNote at [the same] time. So, it was sort of a learning thing for the teacher and us, to learn *altogether and find new things…. Every time someone found something new, if it was helpful, everyone was taught it at that time.*

Some participants mentioned how teachers had gone out of their way to find effective technology for their students to learn to use.

But the way I kind of learned all those things was, my teacher last year actually looked into a lot of the things and she kind of helped me out a whole bunch, since it was the first time [students were using their devices] within the whole entire school. Because we just turned into a BYOD school, bring your own device, so she kind of looked into all these things. And I'm pretty sure she's still using some of them, because when she found one... like the Snapseed one, where you take a picture and you can type onto it, she actually got that so then everybody can have it on their device and doesn't have to worry about losing the paper or anything.

Influence of family

Families do a lot to support children who have LD with their schoolwork. Participants mentioned parents and siblings helping them with homework, reading textbooks and assignments aloud to them, and keeping them organized.

There are 19 chapters in the book, so every single chapter we have to write a summary about it. My mom, whenever I do it with her, she writes extra stuff…. [M]y mom does read [the book aloud] for me because sometimes I can't read it, like it's too much for me, so sometimes she does.

My brother does a lot of this [technical] stuff. He types all his stuff out, so if I need help with anything or if I have a question about something, he's pretty much the one to ask.

As one might expect with this age group, the devices and applications used by participants were bounded by limits set by their parents in terms of what technology was made available and rules about how it should be used.

My dad, again, is really protective, so I don't know the password [of my device] to download things. So I have to either do it at home or wait for hours for him to authorize it.

The reason I got Facebook was because I like designing things. I like the idea of organization, but I'm not good at it. My aunt was playing this app, and I really loved the app, so I got it but it was only on Facebook, so I had to have a Facebook account to play the app. So my dad got me a Facebook account, but he says I can only be friends with people I know on Facebook. I basically just have my family, and I have one of my friends who has Facebook. It's like, "Whoa, you have Facebook! That's not common," because little kids don't really get Facebook anymore. It's more of an adult thing, and I can see why because a lot of young adults that my mom and dad are friends with, they post really stupid stuff.

Family members helped participants learn to use technology more effectively.

Then my mom searched this up on the internet because you can't right click, like there's no right click button on Chromebooks so you just double tap with both your fingers and then all the *options come up and it says stuff like control alt [unintelligible word], control shift Y, control shift I, and stuff like that.*

My cousin teaches me how to type a lot now. My mom wants him to teach me how to type on a computer faster, because I'm not that fast.

[My dad's] job is basically he monitors phones in places, but he used to be a virus guy so he'd go and fix your computer if you had a virus, right. So he's usually very good if I have a problem with my laptop or something or my phone. He's usually pretty good at figuring out a way to make it work without making it super complicated so I can't do it again later.

Perhaps just as importantly, family members acted as models of ways to use technology effectively. The mother, mentioned above who had researched keyboard shortcuts and then taught them to her son, had also taught him practices like setting up bookmarks, and she regularly looked up online information about math concepts so she could help him with his schoolwork. Her son demonstrated similar behavior during the interview, demonstrating how he used some online resources to find out more about his own interests.

Family members also provided participants with opportunities to learn about different games, applications, and devices

My mom's friend had a kid that showed me [Mindcraft] and my cousins showed me it. And my sister and I saw it, and we played it with them. And my brother didn't really know what it was yet. So, my sister and I didn't have our tablets yet, but my brother had his iPad, so sometimes we would sneakily download Minecraft on my brother's iPad. That was kind of funny. We'd just be playing Minecraft for like hours. Those were good memories.

Well, it's a funny story. My aunt, she likes to use iMovie. Whenever she goes on vacation she like makes a trailer for it, and so I have the app. And the trailers give you a template and then you fill in the blank spaces with film. And then you can either make a trailer or your own movie/film thing. I normally use the film thing because it's more creative, there's more things you can do in it.

For my birthday or Christmas, either my grandparents or dad got me this big drone. And it has a camera, and there's an app for it. And because I don't have a phone, we used my grandma's phone. And we put it in the VR headset that they also got me with the kit; and I just put it on, and I can just see the... One time I was in the park, I just put it on… [I was] waving up at the drone. And the drone can just see me waving. It's like, "How am I waving while I'm up here?" VR is pretty cool.

But I also might get, not an iPod but, you know, those ones where it just plays music? I'd probably get one of those. My brother wants one. I would kind of like one. I mean, now on tablets they do have the app, Spotify. But I don't have a phone, I have a tablet and I couldn't just fit that in my pocket, and be like, "Oh, I want to play with this song." And it also tends to take wifi. Well, those little machines don't need wifi and you can pretty much download all the songs you want.

Influence of friends

None of the participants mentioned any friends helping them with technology at school, but one participant had joined a friend, who attended another school, in doing an investment project that was a part of the friend's math unit.

We started this investing thing which was like this fake investment thing where you could invest money in things, and you'll see how much money you would've made it, which was his math unit last year. He made 300% of his money in two months because he's good at math. I think he got lucky though. I invested in a mafia and made 200%, but still ... I don't know what I invested in. It had a long Russian name, and we never figured out how to translate it.

More frequently, participants were introduced to non-school related software by friends.

I went to one of my friend's birthdays, and a few of my friends there had iPads, or tablets, or something. And they had Roblox on them, so they'd play that, and we also played Minecraft. Anyway, so we were playing that, and I was like, "This is really fun!," so I downloaded it on my tablet.

My friends started doing [Twitch] and then I started doing it [about five months ago] and was like, okay. People can donate to you. People can watch you. People can play with you. Why not just try it? It worked out pretty well.

Influence of others

As mentioned earlier, one participant sometimes sought advice from users on Reddit. Another participant was improving his gaming through watching online videos and by playing people he had met online.

Those [games] take a little bit of practice Those are hard. The games I play take many hours to achieve a day. I definitely spend most of my free time on video games… People play. I learn from them…. I do have a lot of people I play with. Not from the school, but just on Discord and things like that. I could just paste the link to my party and people can just join it. Then I could just talk and play with them in my region… Probably more than a couple hours. Many hours a day. Five hours, something like that.

"Messing around"

A number of participants said that they learned how to use technology by just trying things out, although sometimes it was a difficult process to describe.

[Interview asks how he learns to use tech]. I don't know. I just keep, I always mess around at home so it's like, I don't know.

I've used [technology] for a really long time though. I know some parents are like, "We don't want our little kids to be using things like phones and stuff." But I've been using phones since I was one. I have a little cousin, love her to pieces, and she loves using my phone… I was sitting criss cross applesauce and there's this tiny newborn baby sitting in my lap with my headphones on and she's just watching the Wiggles. We're just sitting there and she's just like, "Whoa." I do a lot with technology. It's always been one of my strategies to make people happy like my little *sister. I would just start playing music or something and she'd be like, "Whoa, how did you do that? How did you make me stop crying, whoa!"*

Like this morning, I just went on Google and I'm like, "pictures of sharks," "angler fish," baby dogs, puppies," "kittens" and I'm just seeing what it can do and most of the time when you search it there'll be like off topic things down here [points to screen] where you can just explore. So that's sometimes how I explore.

Participants described times they learned from their mistakes.

Usually I just figure it out, honestly. For instance, this new app that we got, well I got, I play this game or whatever where you have to live the characters, you have to move the character around, you have to give them food and take care of them…. Now, yesterday I was on the app and this new place was being built in my place and there was this cool thing where you got to build your own character or whatever and I was using it but then it shut down my game and I was like, "Well, why did it shut down my game?" And Mom was like, "Hmm." So I had to fiddle around with some things and I did different things and I figured how to fix it. So yeah, now I'm not touching that character-building thing because I don't want it to shut down my phone.

I just learned it myself. I just started out in kindergarten going on random apps and stuff. Then I learned a bit more, slowly progressed, went on a desktop, a lot. Played a lot of games. Learned a lot of stuff and yeah, I just learned if there's a virus and you can tell if it says "Sorry you're..." If I was on Roblox and I couldn't log into my account, I'd know somebody hacked it or I got my password wrong. But I don't get my password wrong.

Discussion

Technology has long been considered a way to level the playing field for students with disabilities. However, in recent years, with its ubiquity in day to day life and in many schools themselves, technology has begun to change the playing field itself. Thus, we have everyday occurrences of people using speech-to-text features to do online searches on their smartphone when it is more convenient to speak than to type, and close-captioning on television and video display screens being used not only by those with hearing impairments, but also by those learning an additional language, gamers, and in noisy environments like airports and restaurants. The principles of Universal Design for Learning suggest that what is good for some may be good for all, and our society seems to be catching on.

The purpose of this study was to find out what kind of technology students with MLD are using to help with their studies and how they are using it. As participants with MLD have a variety of learning needs, in this document I sought to report on the range of their experiences rather than on which applications and strategies were the most commonly used. It takes time to learn what the affordances of technology are, even the common technology that we use every day, so it makes sense to ask students have MLD what their experiences with technology have been.

As the participants were all students with MLD who felt confident using technology, it is no surprise to find out that they appreciated the BYOD policies of their schools. What was more of a surprise, however, was that they felt that they did not use their technology much differently than their peers without MLD did. Using an electronic device in class no longer singles anyone out as "the kid with the learning disability" because now everyone has one, even the teacher. Some of the participants acknowledged an increase in their social status due to their technological knowhow, being the one who could help peers with their computer problems or could act as a technical resource during group projects.

The ubiquity of technology also meant available technological support was widespread. With traditional assistive technology, such as Kurzweil, the student relied on the student services teacher, or school district specialists, for access to the technology and for training in how to use it. However, participants in this study almost entirely used the mainstream devices and applications to which they had regular access, both at school and at home. While participants were able to recall learning recent classroom applications (e.g. OneNote) they also pointed out that they had been using technology since they were very young, gradually learning how to use it over time and through trial and error.

Aside from teachers, technological support and advice came from family members and peers who also often had experience with these same devices and applications, or with ones that had similar features. As well as seeking access to further information through online resources, a few participants reported trying out technologies on their own, a behaviour that a colleague and I have noted in a study of post-secondary students with MLD (Armstrong & Gutica, 2020). I suggest that this kind of technological independence is an important goal for students with MLD.

Of course, technology in itself is not a panacea. It is a tool and does not take the place of informed teachers or well-designed curriculum. Participants remind us that watching a math video or looking up a question about math online does not necessarily mean engagement with the mathematical concept. Technology may help to facilitate learning but using it is not learning in and of itself, even in the case of learning systems, such as Sumdog or IXL, that offer leveled tasks and immediate feedback.

Participants described how using various electronic versions of texts (e.g. electronic, audio, dynamic) and showing their learning through various representations (e.g. PowerPoint or Prezi slides, animations) had become second nature to them, and how some of them were starting to transfer technology skills and knowledge from extracurricular experiences to do their school projects. However, it was interesting to note how math appeared to be considered a subject apart from the others in terms of technological use. Participants described technology for math as being directive and structured (e.g. games, learning systems) or as a way to check accuracy or look up facts – or to cheat! Aside from one participant's use of Excel, there was no sense of technology being used as an exploratory tool for math. The absence of any mention of in-class technology like Smart Boards or online technology such as graphing calculators (e.g. Desmos), dynamic geometry applications (e.g. GeoGebra) or virtual math manipulatives (e.g. Illuminations), among others, was noticeable. It is difficult to say if these things were simply not being used in their classrooms or if the participants just did not happen to report about their use. Given that a couple of participants expressed frustration in their experiences with math, it would seem to be worthwhile to explore the possible affordances that technologies like these might offer

Recommendations

"Just find something that works for you because lots of things don't work for everyone"

With such a variety of issues involved with MLD, the parting advice offered by one participant, above, is wise. In the appendix, I have provided a list of software and applications that students mentioned during their interviews, but given how rapidly technologies evolve and how recent events (i.e. the covid-19 pandemic) have necessarily accelerated people's need to use technology for their formal education, this list is likely already dated. However, the Universal Design for Learning principles – being able to access and act on content in a variety of ways; being able to represent thinking in multiple ways; and being able to engage in learning in multiple ways – all continue to be relevant, as do the participants' strategies of continuing to try new things and to explore what technology can do.

Students

- Keep an eye out for technologies and applications being used by teachers, family, friends, and classmates.
- Let your parents and teachers know when you find technology that works for you.
- Explore the applications that you already have on your devices. They may have helpful features that you haven't discovered yet.

Teachers

- Continue to use online platforms that help students to organize, store and submit their work.
- Post documents in formats that students can both easily adapt for their own needs: for instance, documents that can be typed, written and drawn on, documents that can be read aloud by electronic narrators.
- Continue to offer opportunities for tutoring, and also consider ways that tutoring might be made available online.

- When possible, move beyond the more traditional lecture delivery of lessons and make use of applications that "show" math in different ways and allow students to explore and experience mathematical concepts.
- Suggest reliable age-suitable on-line resources that students (and parents) can access to review, or learn more, about mathematical topics at their own pace.
- Attend professional development events about mathematics and technology. Provincial teacher conferences, offered by the BC Association of Mathematics (BCAMT) and the Saskatchewan Mathematics Teacher Society (SMTS), have excellent offerings, as do school district sessions.
- The number of online resources are growing. For example, #MTBoS (math teachers blogosphere) on Twitter is a growing community that may suggest helpful ideas, and in recent months more virtual math education conferences and workshops are being offered.

Parents/Families

- Continue to encourage and support your child's personal interests.
- Be aware of your own attitude about technology and how you can model positive behaviours in your own use of technology.
- Continue to monitor what your child is doing online and set guidelines for appropriate use.
- Make use of social media to access on-line support. Organizations, including provincial learning disabilities associations, often have facebook pages and twitter accounts. As well, there are several support and advocacy groups for those with learning disabilities (and their families) active on social media platforms where members can both share ideas and resources and develop a sense of community.

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Appendix A: What participants mentioned using

Capturing in-class content

- Audio-recording (cellphone)
- Scanning-pen
- Photos

Accessing class texts

- Electronic readers (text-speech)
- Snapseed

Accessing textbook information

- E-textbooks
- Documents electronically scanned by teachers

Accessing books

- Audio Books
- Video Books
- Hoopla
- Google Play Books

Word processing and revising

- Microsoft Word
- Pages
- Google Read and Write
- Grammarly
- Online thesaurus

Presentations

- Powerpoint
- Prezi

Animation/Design

- iMovie
- StopMotion
- Adobe Draw
- Adobe Sketch

- Adobe Photoshop
- Adobe Lightroom CC
- Unity
- Blender
- Firealpaca
- Pivot Animation
- Pencil 2D

Typing Software

- All the Right Type
- Typeracer

Engaging with mathematics

- IXL
- Mathletics
- Online Math Games (CoolMath, SumDog)

Search engines

- Google/Google Chrome
- Safari
- YouTube
- School district website library

Calculations

- Calculator apps or online calculators
- Excel

Social Media

- YouTube
- Discord
- Twitch
- facebook
- Skype
- Microsoft Teams

Organization

- OneNote
- Fresh Grade
- e-mailing/texting information to parents

- Microsoft Teams
- USB keys

Coding

- Minecraft
- Scratch
- Python
- Genie

Appendix B: Other online resources mentioned in report

Illuminations Lesson Plans and Interactives, National Council of Teachers of Mathematics

https://illuminations.nctm.org/

National Library of Virtual Manipulatives

http://nlvm.usu.edu/en/nav/vlibrary.html

GeoGebra Math Apps

https://www.geogebra.org/?lang=en

Desmos

https://www.desmos.com/