

Teachers' perceived usefulness of assistive technology in Ontario classrooms

Bronwyn Lamond, Shimin Mo and Todd Cunningham

Abstract

Purpose – Despite the positive impact that assistive technology (AT) can have on the academic success of students with learning disabilities, it is often inconsistently implemented or abandoned. It has been established that teachers' perceived usefulness of AT can act as a barrier to classroom AT implementation. The purpose of this study is to expand the current understanding of the challenges with implementation of AT within the classroom environment to inform teacher training on AT tools, improve professional development around AT and address the systemic and practical barriers that impact AT implementation within Ontario classrooms.

Design/methodology/approach – This research examined Grade 6–10 Ontario-certified teachers' (N = 111) perceptions of AT and the variables that predict perceived usefulness of AT. The study used a mixed methods design including a survey consisting of open- and closed-ended items that elicited information about teachers' AT knowledge and training, their access to AT resources, their perception of administrative support for access to and implementation of AT, the usefulness of AT and the barriers to AT use in the classroom.

Findings – An exploratory linear regression was conducted to predict perceived usefulness of AT from AT training, AT resources and AT knowledge and revealed that AT resources and AT knowledge added statistically significantly to the prediction, whereas AT training did not. A thematic analysis of open-ended survey responses and interview data further identified that access, training, Internet and student motivation may influence AT use.

Originality/value – Implications for teachers' AT training and provision of AT resources are discussed.

Keywords Assistive technology, Universal design for learning, High incidence disabilities, Technology integration, In-service teachers, Classrooms

Paper type Research paper

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Assistive technology (AT) is any technology that allows an individual with a disability to increase, maintain or improve their functional capabilities (Edyburn, 2000). AT is a common accommodation for students with learning disabilities (Edyburn, 2000) and a variety of other disabilities, such as autism spectrum disorder (Mirenda, 2001) and physical disabilities (Greer *et al.*, 2012). AT has been deemed a critical component of the inclusion (Edyburn, 2006; Zhou *et al.*, 2011) and academic success (Maor *et al.*, 2011) of students with learning disabilities as it can help them circumvent academic areas of challenge and complete tasks more efficiently and independently (Morrison, 2007). While AT has been shown to improve reading comprehension and vocabulary (Park *et al.*, 2017), writing fluency (Higgins and Raskind, 1995) and motivation to write (Morphy and Graham, 2012), it is often abandoned or inconsistently implemented (Zapf *et al.*, 2016). In fact, abandonment rates for AT may be as high as 30% (Zapf *et al.*, 2016).

To better understand the disconnect between the positive impact of AT reported in research and the practical lack of use of AT, research efforts have focused on examining the perspectives of teachers when it comes to the implementation of AT in the classroom. Researchers have found that teachers' attitudes and comfort level with AT are critical factors for promoting AT use at school (Morrison, 2007; Parette and Scherer, 2004). Teachers not feeling confident enough to implement AT in classrooms has been a longstanding issue. Abner and Lahm (2002) surveyed 79 teachers of students with visual impairment in Kentucky and found that only half of the respondents felt

Received 18 May 2022
Revised 24 October 2022
Accepted 26 October 2022

Funding: The authors acknowledge funding support by the Social Sciences and Humanities Research Council (CGS-D).

competent in teaching AT. Similar findings have been found in studies conducted in Ireland and North-West Nigeria where teachers reported they were unprepared or did not have the competency to assist with AT use (Chukwuemeka and Samaila, 2020; O'Sullivan *et al.*, 2021). Lamond and Cunningham (2020) also examined general education teachers' perceptions of AT use in the classroom. They examined the factors that are correlated with perceived usefulness of AT and found that teachers' knowledge of AT was significantly related to perceived usefulness of AT, suggesting that teachers who know more about AT are more likely to implement it in the classroom (Lamond and Cunningham, 2020). Given that teachers' perceptions are essential in guiding students' use of AT, understanding the factors that impact teacher perceptions can help uncover the underlying barriers in AT implementation and provide potential solutions.

Barriers to classroom assistive technology integration

Appropriate training of both students and teachers is essential for promoting AT use in classrooms, yet current AT training opportunities are still scarce and underdeveloped. For example, Lamond and Cunningham (2020) found that one-third of teachers in their survey indicated that lack of training hindered AT implementation. At the same time, less than one-third of the respondents in the study had preservice training in AT (Lamond and Cunningham, 2020). Other studies have also found that professionals are likely to implement AT when they have more experience, especially previous successful experiences with AT (de Joode *et al.*, 2012; Flanagan *et al.*, 2013) but have reported that they do not receive enough training in AT (Abu-Alghayth, 2020).

Researchers have investigated the status of AT courses being provided during preservice teacher education. Atanga and colleagues (2020) revealed that most of the participants, educators who had experience teaching students with learning disabilities at the elementary or middle school levels, reported that their college did not include AT as part of their degree. Smith and Kelley (2007) similarly found that across 30 universities in the USA and Canada, over half offered a specific AT course, though teacher candidates were not taught to consistent levels of competence. For instance, regarding video magnifiers, a type of low vision device, 5% of the universities taught at an advanced level, while 25% instructed to an awareness or proficient level.

Insufficient access is another salient factor that hinders AT implementation at school (Alves *et al.*, 2009; Atanga *et al.*, 2020; Chukwuemeka and Samaila, 2020; Flanagan *et al.*, 2013). Bausch and Ault (2012) found that a lack of fiscal resources to purchase AT devices was a significant hindrance reported by almost half of their participants. Their finding was consistent with a later study by Abu-Alghayth (2020), who surveyed 92 special education teachers' use of AT in Saudi Arabia, most teachers either agreed or strongly agreed that funding was the dominant reason that prevented them from using AT. Specifically, they reported using low-tech AT more often than using mid-tech or high-tech AT because of limited financial resources. Thus, students who need to use high-tech AT according to their Individual Education Plan may not have their requirements fulfilled. As a result, this may lead to a "cookie-cutter solution" (Holmes and Silvestri, 2012). Specifically, given that there is a limited range of AT products at disposal, students are forced to use the AT that may not fit them rather than having a solution tailored to their needs.

Another factor that leads to insufficient use of AT is the lack of experienced AT providers. Given the vast amount of AT devices and tools that can be implemented to assist students with various needs (i.e. up to 20,000 different tools; Davis *et al.*, 2013), it could be overwhelming for AT users, their families and teachers to keep up to date with the latest AT products (Abu-Alghayth, 2020). Hence, the use of AT may be reduced if not enough personnel resources are provided to meet the mass demand of students with learning disabilities (Holmes and Silvestri, 2012).

Teachers who have more knowledge about AT perceive AT to be more beneficial to their students and are more comfortable using AT (Lamond and Cunningham, 2020; O'Sullivan *et al.*, 2021). However, in a study of Irish teachers' perceptions of AT by O'Sullivan and colleagues (2021), when asked about their own AT knowledge, teachers reported low or no knowledge, meanwhile recognizing that their lack of AT knowledge interfered with students' academic performance. Zhou

et al. (2011) similarly found that teachers were aware of their deficits in AT knowledge and skills as they evaluated their perceived level of expertise to be significantly lower than their expected level in 55 of the 74 AT competencies assessed. It follows that because more competencies are necessary and beneficial for teachers to educate students who need AT, more training is needed for teachers to gain knowledge about AT. Kamei-Hannan *et al.* (2012) found that a formal AT course promoted AT skills development and enhanced teacher candidates' initiatives in seeking additional training. Specifically, participants demonstrated improvements in their ability to use the AT introduced in the course; over 80% of the participants reported being able to use 9 of the 12 AT devices after they completed the course (Kamei-Hannan *et al.*, 2012). In a follow-up questionnaire, they found that participants who reported either proficiency in or an intermediate level of skill in AT were more likely to seek additional training opportunities than participants at an awareness or an emerging level of skill. Thus, it appears that AT training and knowledge are reciprocal.

Perceived usefulness of assistive technology

Previous research has demonstrated that perceived usefulness of AT was influenced by a variety of factors (Chukwuemeka and Samaila, 2020; Lamond and Cunningham, 2020; Nam *et al.*, 2013), and that these factors were different from those affecting the use of general technology (Nam *et al.*, 2013). Nam *et al.* (2013) suggested that these differences exist because there are many unique characteristics of AT compared to general technology, such as unfamiliar usage and necessity for daily life. They also found that result demonstrability (i.e. the AT does what you want it to do, and you know how to make the AT do it) affected perceived usefulness of AT. Additionally, Lamond and Cunningham (2020) found that teacher knowledge of AT was positively correlated with perceived usefulness of and Chukwuemeka and Samaila (2020) found that poor teacher attitudes were a major barrier to the use of high-tech AT in the classroom. Therefore, it seems that the function of AT, knowledge of how to use AT and teacher attitudes about AT are major factors in the continued use of AT. Given that perceived usefulness is a key factor for AT implementation, it is important to ensure that the system governing AT use in classrooms ensures that teachers have the required knowledge to implement AT effectively in the classroom.

Assistive technology implementation in Ontario

In 2021–2022, the Ontario Ministry of Education was projected to spend \$130.6 million on and supporting AT devices for students (MOE, 2021). Funding for AT devices in Ontario is supported by the Special Equipment Amount, which provides funding for the purchase of equipment that is required by students with special education needs and is administered by the provincial government (MOE, 2021). With abandonment rates for AT as high as 30% (Zapf *et al.*, 2016), this abandonment could potentially lead to millions of dollars of wasted education resources and limit the academic success of students with learning disabilities. Also relevant to the present context of AT use in Ontario schools is a movement toward more students bringing personal devices into classrooms and online learning (People for Education, 2019), which have impacted access (both positively and negatively) to devices that support computer-based AT.

Objectives and hypotheses

The goal of the current study is to expand the current understanding of the challenges with implementation of AT within the classroom environment to inform teacher training on AT tools, improve professional development around AT and address the systemic and practical barriers that impact AT implementation within Ontario classrooms. Specifically, the objective of the study is to answer the research questions: (1) How useful do teachers find AT for their students? and (2) What variables predict teachers' perceived usefulness of AT? Previous research has demonstrated that teacher training on AT is critical for effective implementation (Abu-Alghayth, 2020; de Joode *et al.*, 2012; Flanagan *et al.*, 2013; Mundy *et al.*, 2012), that teacher knowledge of AT is consistently reported as a barrier to effective implementation (Flanagan *et al.*, 2013; Lee and Vega, 2005), as is

access to AT resources (Lee and Vega, 2005) and administrator support for AT implementation (Morrison, 2007; Raskind et al., 1999; Reed and Bowser, 2012). Teacher knowledge (Lamond and Cunningham, 2020) and teacher attitudes (Chukwuemeka and Samaila, 2020) are related to greater perceived usefulness of AT, but previous research on the impact of training on perceived usefulness of AT has been mixed (Lamond and Cunningham, 2020; Lee and Vega, 2005). Based on these understandings, it is expected that teachers who have greater knowledge of AT and greater access to AT resources will perceive it to be more useful and will have more positive overall perceptions of AT.

Method

The present study employed a sequential, two-phase mixed methods design. An online survey of Ontario teachers of Grade 6–10 students was conducted to learn about the use of and perspectives on using AT in classrooms, which included a mix of open- and closed-ended questions with a dominance of closed-ended questions (QUAN + qual; Lamond and Cunningham, 2020). Qualitative data were included to complement the quantitative data so that participants could expand upon their experiences using AT in classrooms and add additional information that the survey may not have included. Interviews were also completed with a smaller subset of the survey participants, which allowed the researchers to gain more information from teachers about factors influencing their use and perceptions of AT in the classroom beyond what has been previously studied and included in the survey items.

Participants and procedure

Grade 6–10 Ontario-certified teachers were invited to participate in the study through advertising on social media (e.g. Twitter and Facebook) and by Qualtrics Research Services. In total, 167 teachers responded to the survey and 56 teachers were excluded because they either did not meet inclusion criteria (i.e. they were not Ontario-certified teachers of Grade 6–10 students) or withdrew before completion of the survey. In total, data from 111 teachers (67% female and 33% male) were included in the analysis. Participants were geographically diverse and were from 33 different school boards across the province. On average teachers had been teaching for 12 years ($M = 12.41$, $SD = 7.76$), ranging from 1 to 30 years of teaching. The majority of participants had taken an Advanced Qualification course focusing on Special Education (70.3%). Almost all teachers reported having students with Individual Education Plans in their classrooms (92.8%) and the majority reported that they had students in their classrooms with SEA Claims at the time of the study (65.8%).

Survey participants who had provided their contact information were invited to participate in a 30-min follow-up interview via email. Five participants agreed to be interviewed using secure Zoom software. All five participants identified as women. They taught in five different school boards across Ontario. All names have been changed for the confidentiality of the participants. *Abigail* is a primary/junior (Grades K-6) special education teacher who had been teaching for three years at the time of the interview. *Calla* is a primary/junior (Grades K-6) special education teacher who had been teaching for 14 years at the time of the interview. *Diane* is a primary/junior (Grades K-6) special education teacher who had been teaching for 12 years at the time of the interview. *Bianca* is a principal in a Grade K-8 school who had been teaching for 27 years, and a principal for 13 years at the time of the interview. *Edith* is a high school (Grades 9–12) special education and English teacher who had been teaching for 23 years at the time of the interview. The first author conducted all interviews.

Measures

The online survey was developed by the researchers on Qualtrics (www.qualtrics.com), a secure online service provider for the creation of professional online surveys. The online survey was

previously described by [Lamond and Cunningham \(2020\)](#) and consists of 155 open- and closed-ended items. These items elicited information about teachers' AT knowledge and training, their perception of support with AT, basic computer literacy, their perception of the usefulness of AT and the factors that encourage or discourage AT use in the classroom. The survey items were adapted from measures that were previously empirically validated (i.e. [Lee and Vega, 2005](#); [Nam et al., 2013](#); [Flanagan et al., 2013](#)).

The semi-structured interview was developed by the researchers. It contained items related to teachers' access to technology at school, the training they received on AT, the barriers to integration of AT in their classrooms, the support they receive and would like to receive on AT from administrators, their AT philosophy and questions related to their computer literacy.

Data analysis

Internal consistency of the survey (i.e. the degree of the interrelationship among the survey items) was assessed using Cronbach's alpha for each subscale and it was determined to be acceptable ([Table 1](#)). To examine the variables that predict teachers' perceived usefulness of AT, an exploratory linear regression was conducted. Predictor variables that were entered into the model were AT training (one point per training experience up to a maximum of 3), AT resources (mean of Likert scale items from [Lee and Vega, 2005](#)), and AT knowledge (mean of Likert scale items from [Lee and Vega, 2005](#)), with the outcome variable of perceived usefulness of AT (mean of Likert scale items from [Nam et al., 2013](#)). A power analysis was conducted in G*Power ([Faul et al., 2009](#)) for linear multiple regression with three predictor variables, and the sample size was recommended to be 90.

Survey data from open-ended items were analyzed using a qualitative thematic analysis using [Nowell et al. \(2017\)](#) approach. Initial themes were derived based on the coding scheme, which was based on previous research ([Flanagan et al., 2013](#); [Lamond and Cunningham, 2020](#); [Parette and Scherer, 2004](#)). The first and second authors used the preliminary codes to work through the qualitative data and to assign codes to the data. Instances, where there was disagreement between the two researchers, were discussed until a consensus could be reached. Coded data were reviewed to determine whether the themes encapsulated the meaning of the original responses and to ensure that there was no overlap in themes. An additional theme was added where the researchers felt it was necessary (i.e. account login). Frequencies and percentages were calculated for these open-ended responses and ranked items to determine the factors that are hindering the use of AT in the classroom as reported by teachers.

The additional analysis included a one-way ANOVA to explore whether preservice teacher training on AT differed by the number of years that teachers had been teaching and a one-way ANCOVA to investigate the effect of level of training on the level of AT knowledge when controlling for years of teaching.

Interviews were transcribed by the second author and coded using NVivo software by the first and second authors. An inductive thematic analysis approach, as described by [Thomas \(2006\)](#), was used to analyze the data. The first and second authors began by open coding the data, and then

Table 1 Internal consistency analysis for teacher survey			
Scale	Authors	Reliability statistics	
		Cronbach's α	Items (N)
Student demographics	N/A	0.89	10
AT Knowledge	Lee and Vega (2005)	0.93	14
AT Resources	Lee and Vega (2005)	0.79	3
Perceived Usefulness of AT	Nam et al. (2013)	0.87	8

Note(s): Internal consistency (Cronbach's α) based on the current study data. AT = assistive technology

established themes for the codes. Inter-rater reliability as assessed by the Kappa statistic was fair ($K = 0.4$). The first and second authors discussed and refined coding where there was disagreement to come to final themes for the data.

Results

Teacher training experiences

The majority of participants either did not learn ($n = 50$) or could not recall learning ($n = 14$) about AT during their preservice teacher education program. A one-way ANOVA was conducted to determine if exposure to preservice training on AT was different depending on the number of years that teachers had been teaching. Years of teaching were statistically significantly different among groups of teachers who had received preservice training on AT ($M = 8.47, SD = 6.44, n = 47$), who had not received preservice training on AT ($M = 16.78, SD = 6.58, n = 50$) and who could not recall if they had received preservice training on AT ($M = 10.00, SD = 8.01, n = 14$), $F(2, 108) = 19.61, p < 0.001, \eta^2 = 0.27$. Teachers who had not received preservice training on AT had significantly more years of teaching than either teachers who had received preservice training on AT ($p < 0.001$) or teachers who did not recall whether they had received preservice training on AT ($p < 0.001$).

Most of the 70.3% ($n = 78$) of teachers who had taken a special education advanced qualification course reported learning about AT during this course ($n = 51$). Many teachers reported having attended a talk or workshop on AT at some point ($n = 57$; Table 2). Overall, 78.3% ($n = 87$) of teachers reported at least one AT training experience.

Despite most teachers having received at least some training on AT, when teachers were provided with a list of factors discouraging the use of AT in their classroom (adapted from Flanagan et al., 2013) training was the most endorsed factor ($n = 55$; Table 3). Additionally, training was the second most frequent barrier to AT integration described by teachers in their open-ended survey responses ($n = 17$; Table 4). When the content of teachers' responses about training were examined (Figure 1), the majority did not specify who required more training (50%), followed by students (39%) and teachers themselves (11%).

Several themes emerged from the interview data during inductive coding. First, all five teachers reported that they learned about AT less through formal training experiences, and more through *independent practice* or self-teaching. For example, Bianca said, "I find there's not a lot [of training], and I have to do the learning on my own. And you have to be responsive particularly technology, it changes so fast." At the same time, all teachers noted that they had received at least some type of formal *professional development* on AT during their career, either from the school board or in the form of conferences or workshops on AT. Lack of *time to learn* how to use or implement AT in classrooms was discussed by two participants. Diane stated:

I think time is really precious and teachers need that to be able to learn how to use it, and put it into practice, and think about it, and evaluate it, and not just dive in. They need time. It takes time to develop

Table 2 Teacher AT training experiences

	Yes	
	Frequency (n)	Percent (%)
Did your teacher education program cover AT?	47	42.3
Have you ever taken a Special Education Additional Qualification course?	78	70.3
Did this Additional Qualification course cover AT?	51	65.4
Have you attended any talks or conferences about Assistive Technology?	57	51.4

Note(s): Special education Additional Qualification courses are accredited by the Ontario College of Teachers and are designed to provide teachers with the opportunity to upgrade and gain qualifications in special education (University of Windsor, 2021). AT = assistive technology

Table 3 Factors encouraging or discouraging the use of AT in classrooms

Factor	Percent of respondents (%)	Frequency (n)
<i>Discouraging factors</i>		
Additional training	49.5	55
High cost	45.9	51
Requires additional time to set up and use	41.4	46
Need additional products/computers to use the technology	33.3	37
Little support on how and when to use it	29.7	33
Difficult to use during instruction	25.2	28
Could not figure out how to use it quickly	24.3	27
Difficult for student to use	20.7	23
No knowledge of how to use the product or what it is for	18.0	20
School computers do not support AT	14.4	16
Difficult for you the teacher to use it	10.8	12
Students do not learn anything differently using the AT	8.1	9
<i>Encouraging factors</i>		
Assists students individually	73.0	81
Increases learning	69.4	77
Ease of use for students	50.5	56
Can use it with more than one student	46.8	52
Can use it with several students at one time	39.6	44
Overall cost is worth the benefits or gains it gives the students	35.1	39
Ease of integration into the classroom and instruction	34.2	38
Is easy how to figure out how to use; user friendly	29.7	33
Can quickly set up or customize for student	26.1	29
Know what product is for and how to use it	22.5	25
Little extra training is needed	20.7	23
Low to moderate cost	19.8	22

Note(s): Items adapted from [Flanagan et al. \(2013\)](#). AT = assistive technology. Participants were asked to select any items that discouraged or encouraged their use of AT. Thus, frequencies will total more than the number of participants

any kind of skill. And I always found that was hard, and the demands are getting harder on teachers who are having less time to prep and less time to think and figure things out.

Finally, four of five teachers expressed that they *need more training* or wish that they were provided with more training to support their students. Bianca stated, "If the teachers don't effectively know what to do with [AT], it could just be a source of frustration. It could be a dust collector. So, it's not really fair to teachers or students to just keep dropping computers into people's laps and expecting them to do everything."

Assistive technology resources and perceptions of support

On average, teachers reported a neutral stance with regard to access to resources (5-point Likert scale, $M = 3.24$, $SD = 1.06$). That is, when asked if they had access to enough AT resources, they neither agreed nor disagreed. However, it should be noted that the range of responses was quite high, indicating that there are vast differences across the province in terms of access to AT resources. In addition, responses were negatively skewed (skew = -0.22 , $SE = 0.23$; kurtosis = -0.57 , $SE = 0.46$). We used a Pearson correlational analysis to examine the relationship between how supportive teachers perceive school administrators to be and AT resources. The analysis revealed that there exists a significant positive linear relationship between administrator support and AT resources, $r = 0.51$, $p < 0.001$. Thus, teachers who perceive their administrators to be more supportive have greater access to AT resources. Access to AT was the most common qualitative theme ($n = 18$) when it came to barriers to AT integration and was also

Table 4 Qualitative themes and frequencies for teacher survey

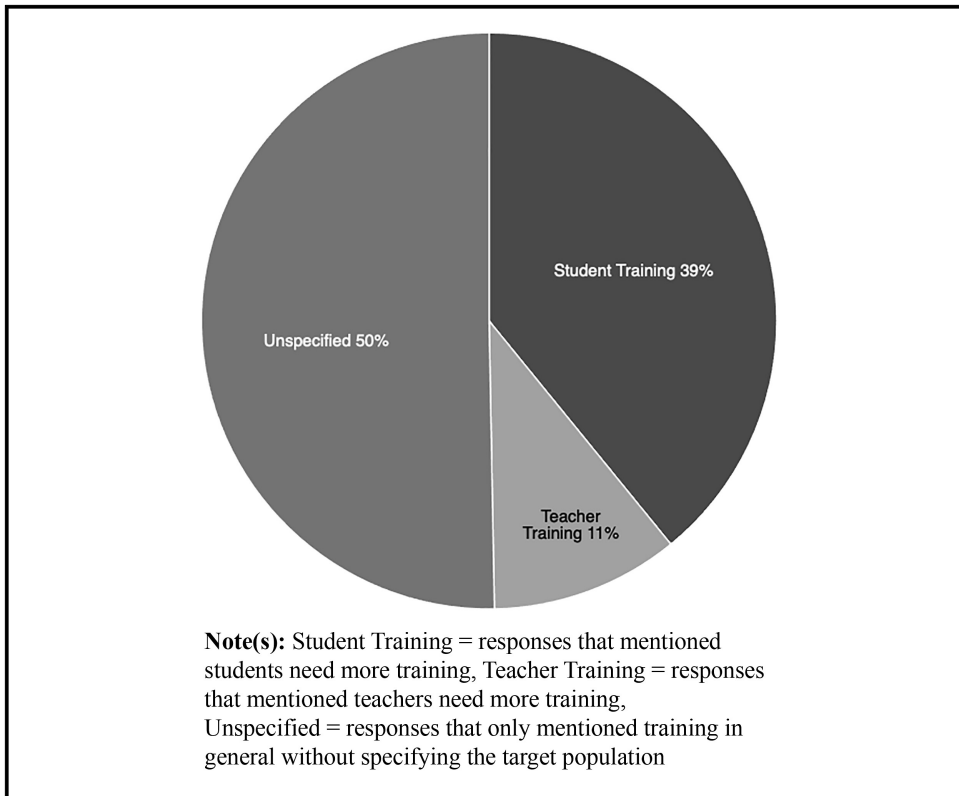
Theme	Example response	Percent of participants (%)	Frequency (n)
<i>Technology implementation</i>			
Internet	“Slow Internet connection”	46.8	52
Access	“Lack of technology available to each student”	25.2	28
Hardware	“Computers are old and slow”	17.1	19
Software	“Apps not being compatible”	12.6	14
Student motivation	“Student distracted or off task on other sites”	6.3	7
Difficulty of use	“When we switch out technologies younger students find it hard to adjust”	5.4	6
Training	“I have not had enough PD in how to use these tools and it is not very intuitive for me”	5.4	6
Speed	“Slow computer connection”	3.6	4
Support	“No money for training of teachers or students”	2.7	3
Account login	“Students ‘forget’ their password and spent half an hour of work time logging in”	1.8	2
Environment	“Limited environments and policy decisions that affect choice”	0.9	1
Stigma	“Other staff that are resistant to using or learning more about technology”	0.9	1
<i>AT implementation</i>			
Access	“Not enough devices”	16.2	18
Training	“Lack of training on specific assistive programs that benefit specific students”	15.3	17
Internet	“WIFI unreliable”	13.5	15
Student motivation	“Students are distracted by Internet capabilities”	9.0	10
Time	“It takes time to make kid understand few things”	8.1	9
Hardware	“Broken equipment”	7.2	8
Difficulty of use	“Number of steps needed to access”	6.3	7
Support	“Lack of tech support”	6.3	7
Environment	“When using speech-to-text, students would like privacy and a quiet space to work”	3.4	4
Stigma	“Sometimes students may be embarrassed to use voice to text software because it singles them out”	3.6	4
Note(s): These are examples of responses from the open-ended survey items. Examples were selected to reflect the prototypical response. Participants’ responses may refer to more than one theme. PD = Professional Development			

prevalent when teachers were asked about the integration of general classroom technology ($n = 28$; Table 4), and four of five teachers discussed access to technology during the interview.

Teachers reported their school administrators to be fairly supportive of technology implementation at their school (5-point Likert scale, $M = 3.83$, $SD = 1.07$). Responses were negatively skewed (skew = -0.99 , $SE = 0.23$; kurtosis = 0.74 , $SE = 0.46$), which was driven by a few participants reporting that their administrators were unsupportive ($n = 5$) or very unsupportive ($n = 6$) of technology implementation. Qualitative responses regarding administrator support of AT were coded as positive (e.g. available support, encourage use), neutral (i.e. collect feedback) or negative (e.g. resistant to use, low training; Figure 2). Despite the quantitative data suggesting that administrators were fairly supportive of technology implementation, the qualitative open-ended responses suggest that administrator attitudes toward AT may act as a barrier to successful implementation.

During the interview, themes related to administrator support, the need for an implementation support person and school board policies were elicited. The three participants who discussed

Figure 1 Perceived population needing more AT training



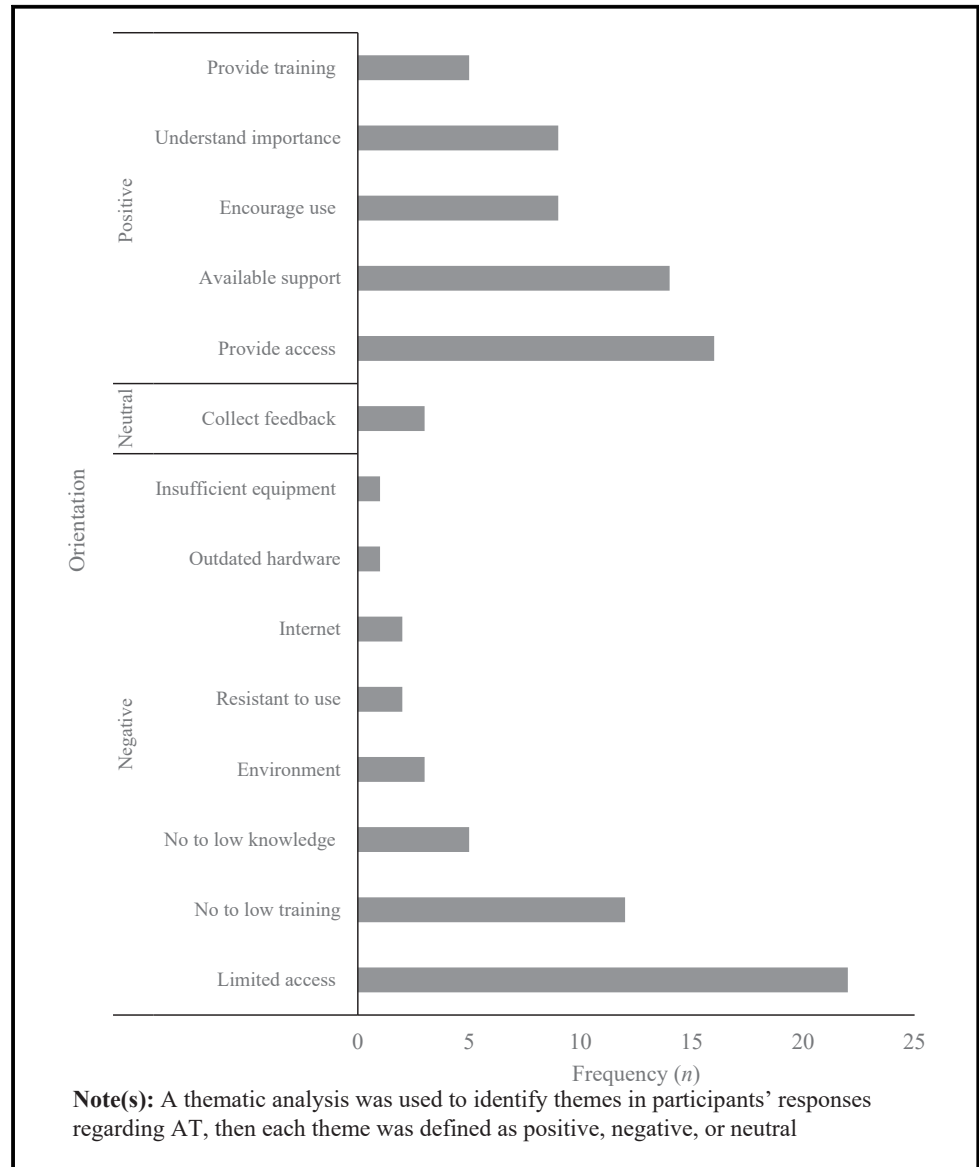
administrator support all had positive orientations toward their administrators, which contrasts with the larger survey sample qualitative results which found that over half of participants had a negative perception of administrator support. All interview participants indicated that support from an *implementation support person*, such as a specialist in AT or technology troubleshooting, would be desirable. For example, Abigail stated, "I think I would love to have like a consultant with the board . . . I would love someone that could come to the school and say, 'Hey, did you know that you could be doing this a different way, or you might want to try this tool.' I would be very, very open to that." Participants' perceptions of *school board policies* varied across interview participants. Some expressed frustration with the lack of support and others reported that their school board has been effectively meeting the needs of their students.

Teacher assistive technology knowledge and skills

Teachers were slightly in agreement that they had enough knowledge about AT ($M = 3.59$, $SD = 0.87$). When asked about skills on common specific AT products (Table 5), teachers reported greater skills on tools that are more general use devices, such as interactive whiteboards ($M = 2.91$, $SD = 1.13$) or tablets ($M = 2.96$, $SD = 1.14$), and on AT suites that are very pervasive within Ontario, such as *Read and Write for Google Chrome* ($M = 2.14$, $SD = 1.52$) or *Kurzweil* ($M = 1.95$, $SD = 1.20$), than on AT to support specific skills, such as *Draft:Builder* ($M = 1.06$, $SD = 1.15$) or *Ginger* ($M = 1.11$, $SD = 1.15$). At the same time, teachers were still reporting only intermediate skills on the general use devices on average with a wide range of skills. When combined, teachers reported their average AT skills to be at a basic level ($M = 1.71$, $SD = 0.82$).

A one-way ANCOVA was used to investigate the effect of level of training on the level of AT knowledge when controlling for years of teaching. After adjustment for the covariate, there was a significant difference in levels of AT knowledge between different levels of training, $F(3, 98) = 4.69$,

Figure 2 Teachers' orientations of perception of support and themes



$p = 0.004$, partial $\eta^2 = 0.13$. AT knowledge is significantly lower in the no training group compared to the medium training group ($M_{diff} = 0.80$, 95% CI [0.090, 1.420], $p = 0.017$) and the high-training group ($M_{diff} = 0.86$, 95% CI [0.152, 1.572], $p = 0.009$).

The interview participants appeared to be highly educated on AT. When looking at their *AT philosophies*, four of five mentioned Universal Design for Learning as a guiding principle, and four of five also focused on the importance of matching AT tools to the specific needs of the learner to help them access the curriculum. It is possible that these participants were above average in their AT knowledge and self-selected to talk more about AT because of their interest in it.

Prediction of perceived usefulness of AT

An exploratory linear regression was conducted to predict perceived usefulness of AT from AT training, AT resources, and AT knowledge. There was linearity as assessed by partial regression

Table 5 AT skills for common AT programs

AT tool/Program	At tool category	Teacher skill	
		M	SD
Tablet	Device	2.96	1.14
Interactive White Board	Device	2.91	1.13
Read and Write Gold	Literacy Suite	2.14	1.52
Dragon	Voice Recognition	1.98	1.31
Kurzweil	Literacy Suite	1.95	1.20
Smart Ideas	Graphic Organizer	1.95	1.35
Mindomo	Graphic Organizer	1.84	1.31
Clicker	Literacy Suite	1.83	1.29
WordQ	Word Prediction	1.76	1.33
Premier	Literacy Suite	1.61	1.35
Natural Reader	Text-to-Speech	1.57	1.38
Inspiration	Graphic Organizer	1.54	1.27
SpeakQ	Voice Recognition	1.52	1.28
Augmentative and Alternative Communication	Communication	1.48	1.30
Switches	Motor Response	1.44	1.26
Snap and Read	Literacy Suite	1.35	1.29
Co:Writer	Writing Suite	1.30	1.27
White Smoke	Literacy Suite	1.12	1.20
Ginger	Editing Assistance	1.11	1.15
Draft:Builder	Writing Suite	1.06	1.15

plots and a plot of studentized residuals against the predicted values after a reflect and logarithmic transformation was applied to the training variable (Laerd Statistics, 2015). There was the independence of residuals, as assessed by a Durbin–Watson statistic of 1.645. There was homoscedasticity, as assessed by visual inspection of a plot of studentized residuals versus unstandardized predicted values. There was no evidence of multicollinearity, as assessed by tolerance values greater than 0.1. There were no studentized deleted residuals greater than ± 3 standard deviations, no leverage values greater than 0.2 and values for Cook’s distance above 1. The assumption of normality was met, as assessed by a Q-Q Plot. R^2 for the overall model was 72.1% with an adjusted R^2 of 71.0%, a large size effect according to Cohen (1988). AT training, AT resources and AT knowledge statistically significantly predicted perceived usefulness of AT, $F(3, 75) = 64.521, p < 0.001$. AT resources ($t = 4.305$, standardized $\beta = 0.371$) and AT knowledge ($t = 6.043$, standardized $\beta = 0.526$) added statistically significantly to the prediction, $p < 0.001$, whereas AT training did not add statistically significantly to the prediction, $t = -0.753$, standardized $\beta = -0.049, p > 0.05$. Regression coefficients and standard errors can be found in Table 6.

Student barriers

During the interview, all five participants discussed themes related to student barriers of AT, including academic and cognitive skills, motivation, stigma and student training. Four participants discussed *academic and cognitive skills* as barriers to AT implementation. Edith stated, “for the

Table 6 Regression coefficients and standard errors for multiple regression

	Unstandardized coefficients		Standardized coefficients		
	β	SE	β	t	p
Training	-0.20	0.27	-0.05	-0.75	0.45
Resources	0.25	0.06	0.37	4.31	<0.001
Knowledge	0.42	0.07	0.53	6.04	<0.001

kids with the working memory [problems], the multiple steps ... becomes problematic and overwhelming." Two participants discussed student motivation as a barrier. When it came to *student training* on AT, again only two participants reported it as a barrier.

The most common theme related to student barriers was *stigma*, with all five participants discussing stigma as a barrier to AT implementation. Diane stated, "[students are] very worried about how they're being perceived by others and from a very young age, they often start to compare themselves and feel different. And they don't like that. They don't want to feel different. They don't want to stand out." In contrast, stigma was the least common barrier to be noted by teachers in the open-ended survey responses (Table 4).

Technical or practical barriers

Technical or practical barriers were commonly reported both on the survey and during the interview. Four of five participants discussed the *Internet* as a barrier to AT implementation during the interview, compared to only 13.5% from the qualitative survey responses (Table 4). Notably, the interviews took place during remote learning due to the COVID-19 pandemic, thus Internet may have been a more salient concern for teachers than it may otherwise have been. *Hardware* ($n = 2$; e.g. Abigail reported, "our iPads are glorified coasters") and *software* ($n = 3$, Edith reported, "the tech wasn't as user friendly") were additional concerns reported by participants.

Discussion

The objective of the present study was to expand the current understanding of the challenges with the implementation of AT within the classroom environment. Based on previous research (Flanagan *et al.*, 2013; Lee and Vega, 2005; Mundy *et al.*, 2012; Nam *et al.*, 2013), it was expected that teachers who had greater knowledge of AT and greater access to AT resources would perceive it to be more useful and have more positive overall perceptions of AT.

The majority of teachers in the present study reported at least one AT training experience and the number of teachers being provided with AT training at the preservice level appears to have increased over time. Despite these training experiences, AT training emerged as the most endorsed factor discouraging the use of AT in teachers' classrooms, was the second most frequent barrier to AT integration described by teachers in their open-ended survey responses, and it was noted as a barrier by all five interview participants. This is in line with previous research in which teachers reported that they did not have enough training or experience in AT (Abu-Alghayth, 2020; Lamond and Cunningham, 2020). The one-way ANOVA revealed a trend toward AT training being more commonly delivered at the preservice level. This suggests that more teachers are gaining AT knowledge earlier in their careers, which may in turn positively impact their perceived usefulness of AT. Interestingly, far more teachers endorsed training as a barrier to AT integration in a checklist-style question (49.5%) than described training as a barrier in an open-response question (15.3%). The interview themes also revealed that teachers gained training through several different methods, the most common being independent practice (i.e. learning on their own). Access to AT devices and the Internet emerged as similarly common themes.

Given that the majority of teachers in the present sample reported receiving training in AT, perhaps the qualitative responses regarding training reflect teachers' lack of confidence in implementing AT rather than a need for more discrete training opportunities. This may also be related to the disparate quality of training experiences, as was the case in Smith and Kelly's (2007) survey of teacher candidates' training experiences. The quality and amount of instruction on AT was not measured during the present study, therefore, teachers may not feel competent or confident using AT even after this instruction. As previous research has found, confidence in AT can impact how often teachers choose to implement it in the classroom (Abner and Lahm, 2002; Chukwuemeka and Samaila, 2020; O'Sullivan *et al.*, 2021).

In terms of access to resources for AT and administrator support of AT implementation, teachers adopted a neutral stance. That is, teachers neither agreed nor disagreed that they had enough AT resources and administrator support for AT integration. The broad range and skewness of responses suggest that within Ontario there are pronounced differences in access to AT itself and information about AT (e.g. where to refer students who need AT, training materials provided by the school board), as well as individual differences in administrator support. Both access to resources and administrator support were negatively skewed which demonstrates that while, in general, teachers had access to sufficient resources and support, there were some teachers who did not. This may reflect the unequal distribution of resources due to a variety of factors that were not measured in the present study (e.g. parents providing privately purchased devices for their children, school-wide fundraising efforts for technology, administrator prioritization of purchasing technology). The qualitative responses demonstrated that access to AT was a common barrier, and that administrator attitudes may act as a barrier to successful AT implementation. The interview themes surrounding administrator support largely confirmed these findings. Teachers generally viewed the support received directly from administrators positively but varied in their orientations toward school board policies and support. All participants indicated that they would find a specific AT support person valuable in helping them manage AT implementation.

When it came to AT knowledge and skills, teachers slightly agreed that they had enough knowledge about AT. They had greater skills on the most commonly used AT products in Ontario (e.g. Read and Write Gold, Dragon), but, in general, were reporting only basic level skills. Additionally, an ANCOVA revealed that teachers who had more training experiences had greater AT knowledge when controlling for years of teaching. This confirms that there is an additive effect of training on teachers' AT knowledge and that they are not simply picking up AT knowledge on the job. This is in line with Kamei-Hannan *et al.s'* (2012) findings that an AT training course resulted in greater knowledge of AT for teachers.

The multiple regression revealed that perceived usefulness of AT was predicted by AT resources and AT knowledge, whereas AT training did not add statistically significantly to the prediction. These results suggest that the more that teachers know about how to use AT and the more access and resources they have for AT, the more likely they are to perceive AT to be useful for their students. Given the vast amount of research which has suggested that AT training is critical for understanding and implementing AT, it is surprising that training did not add significantly to the regression model. In the context of our previous research, however, we found that number of training experiences was not correlated with perceived usefulness of AT (Lamond and Cunningham, 2020), which is in line with the present findings. It appears that there may be another variable impacting AT knowledge other than training. Perhaps the time that teachers are spending time learning about AT on their own time outside of formal training experiences was not captured in the regression.

Other barriers to AT implementation were also elicited from the qualitative data (both survey and interview). These included student barriers (i.e. academic and cognitive skills, motivation, stigma and student training), and technical or practical barriers (i.e. Internet, hardware and software). An interesting finding related to student barriers was the mismatch between the survey and interview results regarding stigma. Specifically, all the teachers in the interview noted stigma as a significant barrier, whereas only 3.6% of teachers in the survey-mentioned stigma. It is possible that the interview questions primed teachers to think about broader barriers to AT implementation than did the survey, or perhaps these teachers work more frequently with AT and thus witness the perceived stigma first-hand. It would be interesting to further investigate the impact of stigma in future studies with students.

Implications

There is a perceived lack of knowledge among participating teachers about AT despite most teachers receiving training on AT. Additionally, all interview participants reported that they gained

much of their AT knowledge through independent practice rather than formal AT training experiences. This may signify a need for specific, ongoing training that directly targets the questions that teachers have about AT. It will be important to ensure that teachers are provided with adequate opportunities to gain AT knowledge to better support students with learning disabilities who are using AT. Previous research has suggested that teachers' AT knowledge are correlated with greater perceived usefulness of AT (Lamond and Cunningham, 2020), which supports this finding.

The present study demonstrates the importance of the sufficient provision of AT resources for classroom teachers. There were several surprising concerns given the context of AT funding in Ontario. First, access to AT was a common theme in qualitative responses, both in the survey and the interviews. As previously mentioned, AT provision is publicly funded within Ontario, so this theme raises the question as to whether parents are being asked to supplement provincially funded AT, or whether students who attend schools who can gain more funding via fundraising are able to gain access to AT more easily, which one interview participant suggested. This disparity may represent an inequitable system of AT access, which could negatively impact the academic potential of students with AT needs who come from lower-income backgrounds. Second, the range of administrator support for AT was large, which may suggest that students and teachers are gaining access to AT devices and training inequitably depending on the school that they attend. Given that, by definition, provision of AT is critical to the academic success of students to whom it is prescribed, these disparities are especially concerning and further investigation into the actual provision of AT within Ontario schools is warranted.

Finally, the present study suggests a need for an implementation support person to be available to teachers for AT implementation. All interview participants suggested that this would be beneficial support to them in understanding how to match the needs of the students with AT, troubleshoot problems with the technology or pair AT with curriculum expectations.

Limitations and future directions

There are several limitations to the present study. First, self-report data can suffer from issues related to bias (Chan, 2009). In terms of the research questions of the present study, self-report was the most efficient way to collect information from a large sample of working teachers and provided nuanced information about their perceptions of the barriers and facilitators of AT implementation. Future studies may wish to measure teachers' AT skills in more naturalistic environments through observation or a series of tasks which teachers are asked to complete on different AT tools to complement the present study and previous surveys of teacher perceptions of AT.

Next, the measurement of the training variable may have impacted the results of the multiple regression. Specifically, teachers were asked to endorse which types of training experiences they had from several options provided. This may have missed other training opportunities that are less common, such as teacher's own time spent researching AT and did not consider the length of each training session. These issues may have resulted in limited variability within the data, which may have masked real-world differences in training on AT. Future research should seek to measure teachers' confidence with AT before and after training experiences rather than just the provision of training itself.

Along a similar vein, the conceptualization of AT knowledge may have limited the findings of the present study. Teachers were required to self-report on their ability to identify and operate AT software, knowledge of AT assessment and the disorders for which they would recommend AT, among other factors, as a measure of AT knowledge. Perhaps it would be more useful to observe teachers' abilities to work within AT programs or report facts about AT to elicit a more relevant measure of AT knowledge.

Focusing on one geographic location provided a thorough representation of the state of AT perceptions and attitudes by teachers in Ontario, which may not be generalizable to other locations. While this approach was selected to specifically investigate teachers' AT perceptions within a particular funding system (i.e. SEA funding provided by the Ontario Ministry of Education), there may be significant differences in these perceptions within different areas.

Based on the AT philosophy and apparent AT knowledge of the teachers who were interviewed, those who volunteered may have a more nuanced understanding of the factors affecting implementation than a typical teacher. That is, teachers who volunteered to be interviewed may have had a special interest in AT and, therefore, different perspectives than other teachers. This provided rich information about the barriers to AT implementation in classrooms but may not reflect the typical experience of a classroom teacher attempting to integrate AT.

Finally, the present study was limited to examining teachers' perceived usefulness of AT. While they can provide information on their perspectives which, according to research, impact the implementation of AT in the classroom (Nam *et al.*, 2013) including the perceived student barriers of AT implementation, they are not the primary users of AT in the classroom. It will be important to examine student perceptions of AT and how their perceived usefulness of AT tools impacts the actual use of AT within the classroom environment to gain a fuller picture of the state of AT use within Ontario classrooms.

Conclusion

Results of this study suggest that while teachers are provided with training on AT and that the provision of this training at the preservice level is increasing over time, training still does not contribute to teachers' perceived usefulness of AT. AT knowledge and AT resources did significantly predict teachers' perceived usefulness in the regression model suggesting that the more that teachers know about how to use AT and the more access and resources they have for AT, the more likely they are to perceive AT to be useful for their students. Identified barriers to AT implementation in Ontario classrooms in the qualitative items included training, access to AT, administrator attitudes toward AT, Internet access and student motivation. Implications of the present study include a need for specific, ongoing training that directly targets the questions that teachers have about AT, access to an implementation support person for AT within the school, and the importance of sufficient provision of AT resources for classroom teachers. Future research may wish to examine how teachers gain AT knowledge beyond formal training experiences, measure teacher confidence with AT before and after training on AT and examine student perceptions of AT as the main users of AT in Ontario classrooms.

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