(Assistive) Technology at the Point of Instruction: Barriers and Possibilities

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ABSTRACT

Assistive technologies which resemble everyday communication technologies (such as text-to-speech features and predictive text) have the potential to remove barriers from the learning environment and allow more access to the curriculum for learners who need support. In the past, some of these affordances required specialized equipment but currently, applications such as predictive text are widely available in everyday life. These newer technologies enable persons with learning challenges to participate more fully in everyday communications, and the "bottom up" effect of these innovations will trickle into schools because the technology is enabling. As these digital applications, programs, and mobile devices become routinely available, and internet access for classrooms improves, more students who might have been labelled in the past as "learning-disabled" will be able to access the curriculum independently. This should support a shift in the discourse from the abled/disabled binary (which labels the students) toward labelling the learning environments instead as more or less enabling. As an increasing number of low- to medium-level tech solutions with seamless interfaces breach previous barriers such as affordability and transferability, the rates of tech adoption in schools will increase beyond the early adopters. As technology adoption increases, it will be easier to differentiate programs and classrooms toward universal learning designs. Technology in the hands of students democratizes education in significant ways and shifts the focus from digital *teaching* to digital *learning.*

1.0 INTRODUCTION

The United Nations Educational, Scientific and Cultural Organization (UNESCO)'s model policy for inclusive information and communication technologies (ICT's) in education defines assistive technologies as follows:

> The provision of inclusive ICTs for learners with disabilities involves removing barriers and enabling all learners to access the same educational opportunities as their peers. Inclusive learning opportunities respect diversity, encourage acceptance and social inclusion and ultimately benefit all learners, not just those with disabilities. [1], p. 11

The focus of this paper is on the growing capability of everyday technologies to *level the playing field* for learners who traditionally have been unable to access the curriculum easily because of how they learn. Technology is evolving to meet the needs of more learners, but there are barriers to the implementation of technology in schools which are summarized in the second section. In the third section, a framework theorizing the acceptance and use of technology is introduced, then applied to schools and classrooms to illustrate how theoretical considerations can help to understand present barriers to technology adoption in education. Next, scenarios are presented that are informed by current events. These scenarios illustrate the potential of technology's reach into society and into schools. When these scenarios are considered holistically, they point to possibilities that technology can democratize education, and help more students access the curriculum and be included in the learning conversation. In the fifth section, the concept of an enabling classroom environment that includes full consideration of the *universal design for learning* using assistive technologies is explored. Finally, the author considers this futuristic enabled classroom in light of the practical implications for adoption that are advanced by the acceptance and use of technology framework. When both the theoretical and the practical considerations are taken into account, optimistic possibilities for more inclusive classrooms emerge which appear to be both possible and within the reach of many more schools and students.

2.0 BARRIERS TO TECHNOLOGY IMPLEMENTATION

While internet infrastructure is available to most Canadian schools [2] and technologies continue to improve and evolve with each new version of the software or device, the implementation of technology into the classrooms for learning purposes is not happening at a similar rate [3], [4]. Early research on barriers to technology implementation identifies two categories of barriers: first-order barrier such as hardware and access; and second-order barriers such as attitudes and beliefs [5]. Appreciation for the complexity of the issues of the implementation of digital learning is growing. Implementation is a complex issue, and, at the heart of it, teachers are seeking digital solutions that will meet the needs of their students [4].

Research on technology implementation at the classroom level reveals that, at present, there continue to be significant barriers to digitally-enabled teaching and learning in Canada and the United States and that classrooms, as yet, are not able to make full use of available technology [3], [4], [5], [6]. Schools may have connectivity, but for students to be able to learn digitally, the classrooms also need to be connected. Most Canadian schools are connected to the internet and have been for the past 14 years [2] but other reports indicate that school connection does not

translate to classroom connectivity [3]. One Canadian government report finds that, while school districts in Canada have invested heavily in hardware acquisitions, 59% of computers in schools are located in computer labs but there is movement toward putting at least one computer in every classroom [4]. The ratio of students to an internet-linked computer is 8:1 [3] by the present available official data but there are indications it could be lower. This puts Canada in the *average* range internationally and close to the US national average of 6:1 of students to a computer [4].

Canada does, however, report an overall rate of 82% of schools using the internet *for instruction*, meaning that the reported average of one computer per classroom is enabling teachers to use computers *for teaching* purposes such as using a projector attached to a computer. American studies similarly show that, while the ratio of computers with internet access to students is reported in some instances to be around 4: 1, the teachers report limited access to the computers in their own classrooms, again noting that the main access to computers for students is not in the general education classroom but presumably in computer labs [6].

In a recent study [4], teachers in Ontario, Canada, which is Canada's most populous province, report a number of positive outcomes from using technology. They can see how technology use in the classroom supports deeper learning and more relevant, current learning for their students. The teachers also find that technology enables more group learning projects for students and gives teachers more time to focus on learners who need more support [4]. In this same report, however, most teachers indicate that they intend to use technology only when they can see a *direct connection* between the use of the technology and the learning expectations; teachers do not want to use technology just for the sake of saying that they are using technology. This same study shows that technology use in Ontario is shifting toward student use of computers for group-learning [4].

A second issue that has emerged is that teachers are being asked to implement newer pedagogies (such as inquiry-based learning) at the same time as they are being asked to implement new technologies [6], [7]. While teachers are starting to feel more comfortable using technology for teaching, they report that they are much less comfortable leading the students in student use of technology and also for using technology for newer pedagogies such as inquiry learning or problem-based learning, for example [7].

Another issue is the provision of technology for students with special needs. When students with special needs are provided with highly technical, proprietary software and hardware in classrooms, there are multiple intersecting challenges for students and teachers. Sometimes the process of providing the specialized equipment can, itself, become formalized through a process where the learner has to be identified as having special needs. In some cases, the learner and his or her parents or caregivers may not want the student to have a label. Another unintended outcome may be that the student feels more isolated by using specialized equipment in class where others in the class are not using technology.

The complexity of these multiple innovations and implementations that teachers and schools are working through has not gone unnoticed. For example, the New England Complex Systems Institute [8] identifies three significant tensions for teachers today as follows:

Tension 1: Finding a balance between the curriculum coverage and meeting the needs of individual students. Teachers who may want to use divergent approaches to meet individual students' needs instead will use more didactic forms of transmitting knowledge in order to prepare students for centrally-administered tests;

Tension 2: Diversifying the teaching method to meet the needs of students of different abilities and cultural backgrounds. While traditional, teacher-directed methods have been efficient in transmitting curriculum knowledge and skills to those students who learned easiest that way, there is growing recognition that all students need to develop their learning skills in order to become more autonomous learners; and

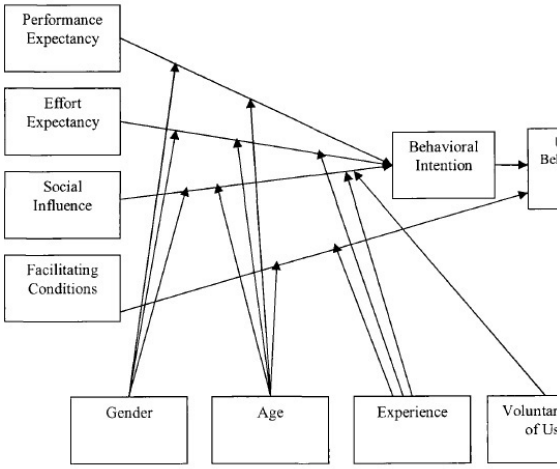
Tension 3: Developing cross-disciplinary approaches for cross-curricular curriculum outcomes. Students will need to solve problems across disciplines in order to meet the challenges of the present era [8].

These three tensions need to be considered when discussing technology implementation in classrooms. Technology responses for classrooms will need to help teachers address the need to differentiate students' learning but not take time away from covering the required curriculum outcomes.

Similarly, Blackwell and colleagues [9] find that technology has not had the intended or anticipated impact on the educational environment that was predicted, and that technology has not delivered the promised enhanced learning outcomes for students. Similar to Ertmer's findings [5], Blackwell et al. find that technology implementation in classrooms is affected by the complex *interplay* of the extrinsic barriers and the attitudes of the teachers [9]. Shapley's [10] study of tech immersion schools (1:1 programs) in Texas has similar findings. She notes that, when the teachers are the "gatekeepers" of student technology, many teachers opt instead for more traditional teaching practices.

3.0 ACCEPTANCE AND USE OF TECHNOLOGY FRAMEWORK

Venkatesh et al.'s Unified Theory of Acceptance and Use of Technology (UTAUT) [11] has been theorized to explain 70% of the variability in technology use. UTAUT identifies three determinants of behavioral intention (performance expectancy, effort expectancy, and social influence); two direct determinants of technology use (behavioral intentions and facilitating conditions); and four contingencies which can alter the effect of the determinants: Gender, Age, Experience and Voluntariness. See Figure 1. [11]



Note: All interactions shown are higher-order terms.

Figure 1. Original UTAUT

This UTAUT framework provides a theoretical grounding for the arguments advanced here considering both the barriers to technology implementation and the possibilities. When this theory is applied, in this case, to the adaptation of technology for teaching and for learning in K-12 classrooms, the determinants and contingencies might be interpreted as follows:

Performance Expectancy would be an indicator of how well the teachers perceive that the technology is going to help them in their teaching goals and performance as well as how well it helps the students to meet their learning goals.
Effort Expectancy refers to how much effort the teacher anticipates s/he will need to put in to implement the technology.
Social Influence refers to the degree to which others in the immediate environments (the school and the home) are using the technology or how the individual teacher feels that s/he *should* be using technology or feels compelled to use the technology.
Facilitating Conditions are interpreted to be what Ertmer [4] refers to as first-order barriers such as the organizational infrastructure or training, support, and access to the technology. The *intention to use* the technology (labelled a *Behavioural Intention* in Figure 1 above) and the *Use Behavior* or the actual use of the technology are mitigated in theory by four factors: *Gender, Age, Experience* and *Voluntariness of Use* (whether or not the technology use is mandated) [12].

This theoretical framework is revisited later when the *possibilities for technology-enabled classrooms using universal learning design* are articulated.

4.0 SCENARIOS

In this section, a series of short vignettes illustrate different aspects of "ground-up" technology implementations which collectively point to the overall democratization of technology in society and in education. Some of these vignettes focus on improving the quality of the assistive technology at the point of instruction, which has the potential to improve learning for all students. Consideration of the UTAUT framework [11] along with more recent innovations in technology within society provide an indication that the winds of change may have already started to impact on education. The changes will likely be more grassroots than earlier changes which were "top-down" district investments (such as significant hardware purchases). These grassroots initiatives may change teaching and learning in ways that will invite teacher responses. It might also be reasonable to assume, that teachers will find it easier to respond to these newer technological innovations. Here are a few scenarios:

Scenario 1: The Economist [13] tells their version of the story of Estonia, which is the story of a country thinking in fresh, new ways and free from legacy technologies. In 1991, at the time of independence, less than 50% of Estonians had a phone line. Reportedly, another country offered Estonia a free analog system but Estonia declined and went digital. In doing so, they were able to *leapfrog* over legacy technologies and systems. Numerous examples demonstrate how they were able to leap forward with technology because they had no previous (legacy, paper) systems to hold them back. The country moved ahead with technology entrepreneurship; Estonia developed the code behind Skype in 2007. The country uses online voting for their elections; 95% of Estonians file their taxes online and it reportedly takes about 5 minutes [13].

Estonians reportedly took a leap and "trusted" the new technologies of the internet and the cloud. All classrooms were connected to the internet by 1998 [13]. Now ICT is a cross-curricular theme in Estonia's national curriculum; teachers are supposed to look favorably on student use of technology rather than restrict it [14].

Imagine a country where the students are required to use their mobile phone for exams. The learning outcomes change significantly when students are not required to memorize content and instead must problem-solve while having the access to content. Solving problems with the information provided (not memorized) aligns more with the reality of the 21st century world of work.

Scenario 2: The faculty of education at the University of Ontario Institute of Technology (UOIT) has provided 1:1 hardware and software for students and faculty for the past eight years, but is migrating toward a technology-enriched learning environment (TELE) program which includes Bring Your Own Device (BYOD). At the present time, so many applications are compatible across platforms, and laptop use is increasingly more user-friendly, so it is no longer an organizational headache if students want to use their personal laptop or technology of choice in order to learn instead of the hardware issued by the university [15]. As more and more cloud-based applications become available across operating systems, universities and school boards can move away from dedicated devices for instructors and

students. This is also a move toward personalization because students and faculty are choosing their devices and operating systems.

Scenario 3: A recent BBC program [16] featured an app developed by Hans Wiberg, called *Be my Eyes*. This phone app allows a user with vision challenges to call someone to assist them. In the BBC program, Vicky in Edinburg uses the *Be My Eyes* app to randomly call a volunteer, who in this case is Kai in the Netherlands. The app chooses someone to respond who is in a different time zone and likely available (e.g., on lunch). At the time of the reporting, 32,600 people who are blind had registered and 457,000 persons with sight had volunteered to respond to the calls. Vicky says in the BBC interview that this app allows her to ask for help in real time. This *tech-enabled, responsive, just-in-time support* characterizes the shift to (assistive) technology at the point of instruction.

Scenario 4: Myo gesture-controlled armbands, as reported by MIT [17], may make it safer for those who use sign language to get help in emergency situations. This technology is being developed at Arizona State university and is part of a larger body of work known as intelligent user interfaces. There are elements of democratization of learning here, as, again a grassroots innovation is changing the environment for learners with special needs who need support with communication. It is another example of a tech-enabled just-in-time support.

Scenario 5: A baby in the United Kingdom had surgery to remove his arm below the elbow. As reported [18], the child, Sol, needed a just-in-time solution. His father Ben Ryan, a lecturer in psychology, was reportedly told by the established medical community to wait until his son was older to have him fitted for a prosthetic arm. But Ben wanted his son to be able to use his arm as he was developing, so the father made the prosthetic arm using a Kinect Box, a scan taken of Sol's other arm while he was sleeping, and a 3D printer. This is an example of individual moving *around* institutional inertia and legacy policies to utilize the available technology when it was needed.

These examples are not intended to be definitive, but they are illustrative of how the combination of the democratization of technology, the accessibility of software tools for innovations, the internet of things, freedom from legacy thinking and legacy systems, and the space that encourages imaginative ways of re-thinking technology are making changes in people's lives that are disrupting the abled/disabled binary [19], [20] that, in the past, has categorized and possibly limited the chances for students who learn differently. In the next section, I examine some school-based applications.

Scenario 6: In a recent tour of international schools dedicated to meeting the needs of students with special needs teachers were asked, "How do you teach the students to communicate? They responded, "Through reading, writing, viewing, and listening exercises." Next the teachers were asked, "How are the ways that you, as adults, communicate with each other?" The room became very quiet. Adults communicate using technology (smart phones, Instant Messages, Snap Chat, WhatsApp, photos, video capture, emojis etc.) and technology's tools such as predictive text and spellcheck. Many students in schools are still taught to communicate using paper and pen, cursive writing, copying, and using dictionaries, texts, and print media.

Scenario 6 presents a disconnect between the communication expectations of the world of work, which is digital, and communication in schools, which has not made the transformation [8], [9], [10]. There is also a disconnect between how students learn within school and out of school [21], [22]. According to Lai and colleagues [22], students choose to use technology when learning in informal settings, and learning within school can benefit from applying the digital skills learned outside of school to learning within school.

Within the cognitive dissonance of these two disconnects: how communication happens in and out of school; and how learning happens informally and formally, solutions are emerging. Some of these solutions have been designed to help students who have been identified as having special learning needs. As these solutions are implemented in schools, they may benefit not just students with learning needs but all learners. In other words, the evolution and democratization of technology can be a powerful lever for making schooling *more accessible* for all student populations.

5.0 ASSISTIVE TECHNOLOGIES AS EVERYDAY INCLUSION

Parents and caregivers are the first teachers for all students. Once they are in school, educators share that responsibility and become their second teachers. The kindergarten curriculum policy in Ontario, Canada refers to the classroom environment as *the third teacher*. In this section, two theoretical approaches to inclusion are examined relative to the third teacher: enabling environments, and universal designs for learning. Both of these approaches to the learning environment focus on inclusion and increased access to the curriculum for all students.

Kalantzis and Cope [23] find that, while students learn differently, these differences are not fixed but change throughout schooling and when students are in different environments. A student who is considered "learning-disabled" in one classroom setting may not belong to the "disabled" group if the instruction is taking place on the soccer field. In other words, societies and groups are dynamic and changing. A person in a wheelchair may not be disabled if everyone else participating is sitting down – it is the environment that has changed, not the person. Also, Kalantzis and Cope find that the difference *within* the groups may exceed the differences *between* groups. For example, students who are in the group called "learning disabled" or

"autistic" will likely have very different profiles from other students who have been labelled in the same category. They encourage us to re-examine these earlier, more traditional group categories which were perhaps helpful in the past but now could be over-simplified and counterproductive. Rather than rely on these earlier classifications, they encourage us to consider how everyone is differently-abled, and how people have different body forms. What needs to change and adapt to them is the third teacher, the classroom environment. This environment needs to be more enabling so that students of all abilities can access the curriculum and be successful [23].

Another guiding principle for inclusion of students with special needs in the general classroom, historically, has been the attempt to provide the student with the "least restrictive environment" [24] (p.5) which has often been interpreted to mean including students with special needs in classes with their age-appropriate peers. Champagne's original interpretation of the least restrictive environment [24], however, include the consideration that the learning environment should be one *that closely resembles everyday communications and everyday life*. Asking the question, "How can communication in this classroom resemble everyday communications and everyday life?" prompts the consideration of how everyday technologies are taken for granted for use in society, but are only now making their way into classrooms. An example of this would be the use of video games on phones. Many people use digital games for "down time" to help them relax and unwind, yet little has been written about how students can (legitimately) use games for self-regulation. Another example might be that, while many people go to the internet to watch and listen to videos for their out-of-school learning, many schools do not yet encourage students to do the same, and maintain the primacy of text-based learning.

The principles of Universal Design for Learning (UDL) [25] provide helpful guides for differentiating the curriculum so that it can be accessed more easily by all students. The goal of applying UDL principles is to help students who have special needs with communication or processing information so that they can be successful however they learn. Technology which is used to help to personalize learning for all students can be used to help students with special needs. The UDL principles were developed from a cross-disciplinary perspective and can apply across multiple content areas.

The goal of every classroom environment should be to reduce barriers to students' learning, help them to access the curriculum, and assist them with learning independently. The principles that fall under the Universal Design for Learning (UDL) provide guidelines for how classroom environments can remove barriers, compensate for areas where students have challenges, provide alternate ways for students to access the curriculum, and help students to learn based on their strengths. The first principle, *multiple means of representation,* means that information and content can be presented to students in different ways. As the technology of text-to-speech improves, students who learn better through listening can use their phones or mobile devices to "read" the materials to them. They can also investigate other sources beyond text which teach about concepts (e.g., videos). As individuals, we all gather information differently (orally, visually, kinesthetically). We also organize it in different ways. How we see, how we hear, and how we read are all recognition tasks. If classrooms can use technology to allow students to listen for their learning as well as read for their learning, this provides students with more ways to access the curriculum and to be more independent as learners.

The second principle of UDL is to provide for *multiple means of expression*. Students should be encouraged to express what they know in different ways. As individuals, we plan and perform tasks differently. We organize our thoughts and express our ideas differently. Writing a poem and designing a piece of sculpture are means of expression. Students should be permitted to show what they know in different ways beyond pen and paper.

The third principle of UDL is *multiple means of engagement*. Students differ in their interests, how much they will engage with a topic, and how they will persist with their learning. When new learning is presented to students, it needs to be presented in different ways in order to stimulate students' interest in the topic and their motivation to learn, which are elements connected with the affective dimensions of learning.

As technology continues to evolve, becomes more widely available in open-source options, and becomes more portable, schools should consider how low to medium level, cost-effective technology solutions can help students of all abilities feel included in the classroom. Low-tech solutions are more easily implemented and require less teacher training time. For example, digital notebooks used by students in small groups allow students to learn through different modalities without identifying that one student needs the auditory aids to process the information. The Google Chrome extension "read and write" was once considered assistive technology, but now can be available for any student in the class under a district license. Students can use it to have the words read out loud to them, or they can also use it for speech to text or they can also use it for predictive text. In this case, the technology has advanced beyond earlier forms of speech to text such as Dragon Naturally Speaking which needed to be more closely tuned to the individual user. Newer applications have interfaces that are more user-friendly and they look like everyday technologies.

Lai and colleagues suggest that schools can take much more advantage of the skills that students have developed in their informal learning out-of-school [22]. All teams, including learning teams, function optimally when there is agreement that each person brings an expertise (skill set) and experience (knowledge) that can contribute toward solving problems. In the present era, students spend a significant amount of time learning in their out-of-school time using technology. Teachers can take advantage of students' expertise with technology. This requires teachers to shift

from their positions as the holders of the knowledge and instead help students articulate what they know and then build on their prior learning. In other words, teachers need to grow students' capabilities to answer the students' own questions. When the teacher resigns his or her role as the holder of knowledge, there is less dependence on students to respond with right answers and instead focus on inquiry.

6.0 IMAGINE A LEARNING ENVIRONMENT WITHOUT BARRIERS

Venkatesh's et al.'s unified theory of acceptance and use of technology [10] discussed earlier, identifies that technology will gain acceptance when the amount of effort required to use the technology is matched to the performance outcomes from the technology. At the present time, technology innovations are approaching the point where there are multiple low and mid-level tech interventions that can help to make the curriculum more accessible to learners. In practical terms, here are some areas that schools can consider when offering assistive technology supports:

1. Give technology support which is *intentionally-disguised* as everyday practices and avoid the stigma associated with *difference* for students who want to fit in and feel like part of the class.
2. Shift the discourse off the disability/ability binary to include a language that acknowledges that we are all multiply-abled in different areas, and in different environments.
3. Shift from the historical deficit ideology to an assets-based focus; find the skills that students can do, and build on those strengths.
4. Revisit the original description of the "least restrictive environment" to see that it was focused on building conditions that closely resemble everyday communications and everyday life.
5. Identify barriers in classroom environments. Examine all the legacy norms and expectations that may be creating barriers (e.g., hand-written notes).
6. Embrace the diversity in the class, not just diversity of ability, but all forms of diversity.
7. Seek first the low- to medium-level technology solutions as the technology evolves to bridge more gaps for students to access the curriculum.
8. Let students demonstrate what they know in diverse ways;
9. Consider that you do not need to convince the students to learn in new ways. They already know this.
10. Make a list of your legacy learning traditions and make room for new ones. For example, do you screen for kindergarten readiness based on their recognition of letters or on their recognition of icons and emojis?

Imagine a classroom that has no barriers for the students. They can record the teacher's explanations and play it back at will. They can access the curriculum through textbooks, through websites, or using text-to-speech apps. They can highlight words to learn how to pronounce them, translate them, or define them. Spell-checkers, grammar-checkers and predictive text help them to formulate their thoughts into sentences. They can pull out ideas and concepts, highlight them, and re-organize them using software that provides graphic organizers. They use multi-modal approaches to assist them in presenting their learning.

Imagine a classroom environment that provides multiple safety nets for learning, and where there is always more than one right answer. With every student using different technologies, and using them differently, those students who depend on particular aspects of assistive technology in order to learn are matching the classroom norms in their studies. Edyburn [26] reminds us that,

> Assistive technology has the potential to enable people with disabilities to live, learn, and work more independently through the application of specialized technologies that reduce, eliminate, or minimize the impact of a disability. [26]. p.1

The wave of assistive technology as everyday learning transition has already started, and, as the time between technology advances becomes shorter and shorter, the wave to democratize learning may happen sooner than anticipated by educational institutions. If we insist that all children must learn to read by decoding and word knowledge, we run the risk of privileging a traditional learning technique that is not accessible to all students. Parr [27] reminds us that assistive technologies, and especially text-to-speech technologies allow struggling readers to work with their peers and follow the same curriculum as the other students. More than that, providing an enabling environment through technology that looks like every day learning tools allows students to participate in the discourse [27] and engage in their classrooms as full participants. This is the essence of fulfilling the promise of a right to an education.

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