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Assistive Technology in Education:

Universal Access, Barriers, Teacher Readiness, and the Path to Meaningful AT Adoption

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Introduction

Assistive Technology (AT) plays an important role in creating an inclusive school setting for all students. AT serves two main functions in educational settings. First, it supports individuals by enhancing their abilities to help bridge the gap created by diverse learning needs or disabilities. Second, it offers alternative ways of approaching tasks, allowing all learners to access and engage with learning more effectively (Fernández-Batanero et al., 2022). In addition, the use of AT enhances inclusive education by increasing student participation (Park & Manning, 2023), and supporting the development of communication, cognitive, and social skills (Park et al., 2022), while also improving access to engaging and meaningful learning experiences (Mukhtarkyzy et al., 2025), particularly for those with disabilities.

Formerly limited to classrooms with adequate funding and resources, AT is increasingly embedded in mainstream educational technology, making it more accessible for students and teachers alike (Ludlow, 2014). While AT use was originally sought to close the learning gap for students with disabilities, its allyship with Universal Design for Learning (UDL) prompts its use to create classrooms that are accessible to all students. With the shift to more mainstream, technology-rich learning environments, AT serves as a tool to bridge the gap of students' academic weaknesses (Alnahdi, 2014), empowering students with the tools that, among other skills, improve reading comprehension and vocabulary, writing fluency, and motivation to write (Lamond et al., 2020).

Despite the growing availability and greater need for AT within the modern classroom, many pre-service and in-service educators lack the training and ongoing support necessary for its adoption and sustained use (Park et al., 2022; Park & Manning, 2023; Van Laarhoven et al., 2012). Additionally, barriers such as time constraints (Schaaf, 2018), lack of funding for (Atanga

et al., 2020; Fernández-Batanero et al. 2022; McNicholl et al., 2020; Schaaf, 2018) and technical issues with AT devices (Schaaf, 2018), among others, limit the use of AT in the classroom. While professional development has long been explored as a route for increased AT implementation, extensive research reveals that in-service training alone has not led to long-term adoption (Van Laarhoven et al., 2012).

Given the current situation described above, this paper explores the following questions: 1) How can the integration of assistive technology (AT) in educational technology enhance learning for all students in inclusive classrooms, and 2) What key factors influence its successful adoption by teachers considering increasingly universal access to AT?

Literature Review

This paper examines research pertaining to the growing use of AT universally through EdTech integrations and AI embedment, current AT integration within the classroom, pre-service and in-service teacher training, challenges in implementation, teacher perceptions, and promising strategies for teachers' future sustained AT use. Literature was sourced using Academic Search Complete, ERIC, and Google Scholar; keyword combinations included "assistive technology in education", "universal design for learning", "inclusive classrooms", "teacher training and AT", "barriers to AT implementation", "embedded assistive technology", and "technology integration and special education". This searching process was led by an initial and flexible draft structure, ultimately shaped by the literature itself. The initial 12 articles were summarized in a literature table, which can be found in Appendix A.

Assistive Technology in Educational Technology and Universal Access

The presence of AT in modern classrooms is no longer limited to specialized devices that provide a bridge for students with disabilities in isolated instances. AT, met with the innovation

of Educational Technology (EdTech) and its growing prominence in Artificial Intelligence (AI) within these programs, has widened its possibilities for use in both inclusive and mainstream classrooms and for all students. This marked shift from traditional AT use to its embedment in all aspects of education uncovers the growing universality of this technology and a broader understanding of AT in supporting learner variability in accompaniment or in lieu of disability.

Across all domains, technology continues to advance rapidly, becoming increasingly available in educational contexts, with AT converging with more mainstream technologies through applications (Ludlow, 2014). These devices and applications, many of which were initially intended to support individuals with disabilities, are now utilized by and valuable to diverse populations, specifically students in school settings. For example, both Microsoft and Apple provide "off-the-shelf", readily available and embedded accessibility features that are easy to use (Koch, 2017). Similarly, Licwinko (2024) found that inclusive co-taught classrooms commonly used accessibility features, including text-to-speech, digital timer or focusing tools, word prediction software, proofreading tools, and speech-to-text. These and other accessible technologies allow individuals to shape their learning experience and accommodate their needs, whether formally identified or not, employing features such as text font adjusters (Ludlow, 2014), screen magnifiers (Koch, 2017), and other built-in reading and writing supports.

Embedded features in everyday educational technology bridge the gap for students with disabilities, assisting those with reading, physical, learning, or attention difficulties while also providing benefits for *all* students (Koch, 2017). These tools not only provide targeted support but also enhance access for the student population as a whole, reflecting a shift toward universal access in inclusive classrooms. For example, captions, while initially intended for individuals who are deaf or hard of hearing (DHH), aid in comprehension, attention and memory for highly

literate and hearing adults and college students, leading to better retention of brand names in advertising (Brasel & Gips, 2014, as cited in Gernsbacher, 2015) and course content (Steinfeld, 1998, as cited in Gernsbacher, 2015), respectively.

Regular AT use within inclusive classrooms aligns with the principles of Universal Design for Learning (UDL), providing tools that allow for multiple means of representation engagement, and expression (Koch, 2017). Messinger-Willman & Marino (2010) offer an excellent illustration of this concept, creating a parallel between curb cuts in sidewalks, explaining how such features (i.e. curb cuts) initially designed for individuals with disabilities ultimately serve a wider population than initially intended, lending themselves to those with temporary disabilities, cyclists, individuals pushing strollers, delivery carts and the like. This idea has been echoed and extended in educational contexts by Koch (2017) and Gernsbacher (2015), further creating parallels to universal design in AT.

Research further supports the connection between AT and UDL, with computer-embedded assistive technology enabling accessibility in educational design to the greatest extent for individuals of all ages and abilities, promoting maximum inclusion (Alnahdi, 2014; Story et al., 1998, as cited in Koch, 2017). Koch (2017) discusses the enactment of UDL principles extending beyond the needs outlined in IEPs and encompassing all students' learning requirements and differences through the use of AT, including tools used within general education settings. Just as AT lends itself to fulfilling UDL principles in practice, so too does this effort provide for and fulfill the needs of all students, thus improving the curriculum as a whole (Alnahdi, 2014). This reciprocal relationship benefits diverse learners as it incorporates AT seamlessly into design rather than in an attempt to retrofit to suit individual learners.

It is important to recognize that the impact of AT implementation extends beyond

academics while also acknowledging that any and all positive impacts, including the expansion and development of social skills, ultimately support students' ability to engage with the educational environment. AT tools of all variations allow students to gain critical emotional and interpersonal skills (Mukhtarkyzy et al., 2025). Both Fernández-Batanero et al. (2022) and Mukhtarkyzy et al. (2025) conclude that the development of these important skills contributes to greater student participation and autonomy while simultaneously providing a more holistic learning environment. Promisingly, achieving these feats is more attainable than ever, with rapid advances in AT allowing teachers to provide the highest quality, technology-enhanced education (Alsolami, 2022). In current practice, assistive technology is offered in greater range and power, costing less than ever before (Ludlow, 2014). Provided optimal access and fewer budgetary constraints, it is the responsibility of educators, both special and general educators alike, to provide appropriate AT accommodations as well as high-quality education and accessibility to all learners (Park & Manning, 2023).

Despite the undeniable and ever-expanding emergence into mainstream educational settings and the benefits it provides diverse student populations, the implementation of assistive technology in the classroom remains inconsistent (Lamond et al., 2020; Zapf et al., 2016). While AT is becoming increasingly accessible, its integration into the classroom setting remains determinant of a complex set of factors, including teacher-related barriers, student-related challenges, technical and logistical limitations, access and funding disparities, gaps in training and professional development, and a lack of administrative support (Lamond & Cunningham, 2020; Lamond et al., 2022).

Current State of Implementation of AT in Inclusive Classrooms

According to a teacher survey cited in Park et al. (2022), the majority of special and

general education teachers (93.7%) reported that they neither used nor requested AT services, nor did they consider AT when developing IEPs for students with disabilities (Alkahtani, 2013). With assistive technology bridging the learning gap for students with IEPs, it is imperative to consider its use; furthermore, teachers of students with disabilities who deem AT essential to their learning experience need to understand the technology thoroughly, in order to select, implement and monitor it successfully (Messinger-Willman & Marino, 2010). As summarized by Park et al. (2022), researchers have identified several critical barriers to effective AT use, such as a lack of technological resources and teacher readiness. These barriers range from broader systemic issues to more menial day-to-day concerns. An example of this is teacher-reported internet unreliability, with various discussions relating to bandwidth and Wi-Fi issues arising alongside technology use in the classroom (Lamond & Cunningham, 2020; Lamond et al., 2022; Licwinko, 2024). It is important to consider all barriers preventing the full extent of AT use in inclusive classrooms as part of a wider spectrum of interrelated problems.

Barriers and Conditions Impacting AT Implementation

Teachers have cited inadequate time as a barrier, both in the preparatory and instructional stages, regarding their use of AT in the classroom. Illustrating this, Lamond and Cunningham (2020) cite teachers reporting insufficient time allotted to the preparatory and planning process, thus influencing its effective implementation. They also expressed concerns regarding their inability to effectively solve technical issues that may arise while managing the class as a whole. Mirroring this concern, Schaaf (2018) noted that when teachers spend an inordinate amount of time addressing unanticipated technical concerns, they lose out on valuable instructional time, requiring them to dedicate resources to troubleshooting, particularly in the absence of a technology specialist. Additionally, teachers reveal time constraints as a factor presenting

difficulties with ongoing professional development engagement (Licwinko, 2024). Similarly, time constraints trickle down to teachers' ability to provide their students with AT training, despite the development of new and valuable technologies (Zhou et al., 2012). Time limitations also impact collaborative processes that allow for successful AT integration, with teachers reporting minimal co-planning time for ongoing and sustained use in the classroom (Licwinko, 2024).

Other barriers pertain to student-related factors. It is important to recognize that assistive technology, like the classroom itself, is subject to the same human complexities and variability in its implementation. Students, both in their individual differences and in their relations with peers, provide a setting of constant flux for AT integration. Scherer (1993, 2005) as cited in Zapf et al. (2016) outlines four distinct user groups regarding AT, including "users, optimal or reluctant/partial users, and non-users due to avoidance of use and non-users due to abandonment of use" (p. 38). The literature documents various contributing factors to students' engagement with AT, including differences in academic and cognitive skills, limited training or support, low motivation, distraction, improper use of AT devices, not charging the devices themselves and stigma associated with increased visibility in the classroom (Lamond et al., 2022; Lamond & Cunningham, 2020; Licwinko, 2024; McNicholl et al., 2023; Zapf et al., 2016). It is important to understand these as interrelated challenges, with all factors having an impact on student AT use. All of these factors have an ebb and flow of push and pull – one factor influencing another, then another, and then vice versa. For example, Lamond and Cunningham (2020) note that student motivation and students not charging their devices are among the concerns affecting AT use; however, causal relationships remain undetermined, and it is unclear whether such behaviours are due to disinterest, forgetfulness or otherwise, indicating vast social complexities and

influences.

Adding to the nuance of student-related barriers is the stigma associated with the unwanted attention that assistive technology can bring, as it increases visibility to an otherwise hidden disability among peers (Lamond et al., 2022; Lamond & Cunningham, 2020; McNicholl et al., 2023; Zapf et al., 2016). Just as these real-time identity challenges can impact student use of AT, so too can distraction, with AT cited in the literature as being an easily accessible gateway to games or used for non-instructional purposes (Licwinko, 2024). Nonetheless, participants felt this issue could be easily overcome, suggesting certain, and perhaps broader, optimism about addressing student-related barriers.

Although assistive technology is designed to bridge gaps and provide equal access to educational offerings, a persistent irony remains: Access to AT itself is often interrupted by deeply ingrained systemic issues. The difficulties of access hindering the implementation of AT are mainly associated with economic factors, lack of adequate support or lack of funding (Atanga et al., 2020; Fernández-Batanero et al., 2022). Funding issues are particularly apparent in rural school settings due to the discrepancy between the high cost of devices and limited resource allocation (Fernández-Batanero et al., 2022; Koch, 2017). In Ontario, Canada, the AT provision is publicly funded, leaving access to supplementary costs potentially feeding the divide in that they may require parental financial contributions or fundraising efforts directly reliant on socioeconomic context (Lamond et al., 2022). Budgetary constraints are the most common and direct barrier to accessing assistive technology in schools (Atanga, 2020; Park et al., 2022), though while this stands true for more costly equipment, readily available and embedded assistive technology may bridge the digital gap (Koch, 2017).

Collaboration, Teacher Responsibility and Administrative Support

Significant barriers to the effective implementation of assistive technology include a lack of effective collaboration, clearly defined roles, and administrative support (Atanga, 2020; Lamond et al., 2022; McLaren et al., 2006). Research consistently points to compartmentalization, whereas teachers fulfill the roles perceived to be expected of them, tasking implementation to the special education teacher (McLaren et al., 2006). This study cites that general education teachers lack comfort in taking ownership of students using AT devices in the classroom, erroneously placing all responsibility on their special education teacher counterparts. Teachers continually rely on technology experts, with their availability arguably justifying a shift in ownership and the implementation role altogether (McLaren et al., 2006). This heavy reliance on special education teachers or technology experts prompts the shift to preparing *all*, namely general education, teachers to have the wisdom and flexibility to effectively integrate technology into the classroom, with further abilities to troubleshoot issues as they may arise, thus freeing up school staff to be more proactive role in supporting teachers and students (Schaaf, 2018).

Further compounding the inability to successfully implement AT within the classroom is the lack of administrative support. Atanga (2020) and Lamond et al. (2022) cited administrator attitudes as barriers, with school or district leaders resisting or lacking the necessary prioritization of AT. Additionally, research shows these issues to be long-standing and persistent, citing state and local administrations' lack of specific guidelines for AT use for IEP teams (Messinger-Willman & Marino, 2010). In some instances, this issue arises not as a passive lack of support but rather as an active withholding of information. Schaaf (2018) describes a school where administrators, citing little to no discretionary funds remaining for the purchase of additional devices, choose not to inform teachers of new technology. This deliberate information

transfer gap leaves progress at a standstill, with teachers uneducated and underprepared, incidentally limiting engagement with AT and reaping the benefits of inclusion.

Teacher Preparation, Training and Readiness for AT Integration in the Classroom

Among the most documented barriers to successful AT implementation in the classroom is the issue of teacher preparation, training and readiness (Lamond et al., 2022). This section explores the current climate of teacher training and readiness for assistive technology and how the current framework impacts its meaningful and sustained adoption.

Although difficulties in implementation are subject to situational variance, teacher preparation and training, both at the preservice and in-service levels, remain one of the most significant barriers to meaningful integration in inclusive classrooms (Fernández-Batanero et al., 2022). While teacher training and ongoing professional development have been long recognized as a necessity for regular and sustained classroom adoption of traditional AT, more accessible AT through software and educational technologies (EdTech) also requires targeted support (Koch, 2017). Despite the growing and differentiated emergence of AT, teachers report merely modest knowledge and skills necessary for successful and long-term integration, citing a lack of formal training and substitution of self-acquired education due to personal interest (Lamond et al. 2023; Lamond & Cunningham, 2020; Alsolami, 2022).

Limited Training and AT Knowledge Deficits

The inclusion movement requires teachers to fulfill the responsibilities of providing a high-quality inclusive education, making necessary adjustments for students with disabilities (Park & Manning, 2023). This issue proves persistent, with long-standing issues in recognizing and channeling the full range of benefits of AT, making questionable the realization of the 1997 amendments to the Individuals with Disabilities Education Act (IDEA) (Abner & Lahm, 2002).

This sentiment is echoed in teachers' self-reported AT knowledge, with many (72.4%) reporting "little to no knowledge" about assistive technology and only 1.6% reporting "good knowledge" (Alkahtani, 2013). Even special education teachers report a lack of assistive technology knowledge at a fundamental level (Messinger-Willman & Marino, 2010).

It is well documented that inadequacies in AT knowledge act as a barrier to implementation in the classroom (Licwinko, 2024; Park et al., 2022); this indicates that individuals hired after graduation are not equipped with sufficient knowledge or skills pertaining to providing high quality AT services for students (Bausch & Ault, 2012). Promisingly, Lamond (2023) found that teachers with more training exposure acquired a greater knowledge of assistive technology, even when controlling for years of teaching. Additionally, younger teachers have been found to be more confident with AT use than older teachers (Lamond & Cunningham, 2020; Zhou et al., 2012). This generational shift is encouraging; when paired with meaningful training both at the pre-service and in-service levels, this could produce incoming educators with increased AT readiness.

It is important to note that many educators are entering the profession with inadequacies in AT knowledge because the very institutions responsible for training them often lack the expertise or formal training (Bausch & Ault, 2012; Park et al., 2022; Schaaf, 2018; van Laarhoven et al., 2012). This reinforces the need for educators at all levels to be equipped with the foundational knowledge required to both support inclusive learning and train others effectively.

Pre-Service Training Realities

A sample of 162 higher education institutions, all special education in nature, revealed that coursework in AT was required only within a range of 25-33% of all courses (Judge &

Simms, 2009 as cited in Bausch & Ault, 2012; Park et al., 2022; van Laarhoven et al., 2012). Van Laarhoven et al. (2012) echo this sentiment, stating that few universities provide certification or training in assistive technology. More recent literature cites educator admissions claiming that their college did not include *any* requirement for AT as part of their degree (Atanga et al., 2020; Lamond et al., 2022). Additionally, of the limited programs offering AT coursework, relatively few required that students demonstrate knowledge surpassing basic competence (Bausch & Ault, 2012; Koch, 2017).

Van Laarhoven et al. (2012) documented that in-service training in teacher preparation programs is impacted by several factors, including: "(a) lack of faculty expertise with AT; (b) limited space in the curriculum for additional content; (c) lack of resources (e.g., hardware, software, devices); and (d) the perception that AT is only used with a limited number of students" (p. 34). Many higher education programs lack access to necessary AT devices, resulting in limited opportunities for practical, hands-on experience, often simple AT introductions or video instruction (Bausch & Ault, 2012; Schaaf, 2018; Park et al., 2022). Compounding the issue are reported deficits in monetary resources, time, personnel, and training infrastructure, which prevent institutions from delivering robust AT instruction (Bausch & Ault, 2012; Park et al., 2022).

Despite these challenges and considering our technology-dependent culture, comprehensive pre-service AT training remains imperative for its successful implementation (Zhou et al., 2012); its absence presents a barrier to the students who need it most (Jones et al., 2021). Purposeful AT program integration should focus on establishing the philosophy that all educators hold responsibility for AT use and educating all students, integrating AT into the curriculum, monitoring and evaluating student progress, and implementation; this instruction

must reach beyond basic competence (Abner & Lahm, 2002; Bausch & Ault, 2012; Hall et al., 2012 as cited in Koch, 2017; McLaren et al., 2006).

In-Service Training Realities

Similar to shortcomings presented regarding pre-service training, in-service training severely lacks the robustness required for true meaningful integration. The climate of in-service education has not shifted greatly over the years, with common trends including short-term, surface-level professional development workshops that do not provide deepened knowledge and proficiency (Abner & Lahm, 2002; Lamond & Cunningham, 2020; Messinger-Willman & Marino, 2010).

In-service training and professional development in AT lack the ability to equip educators with necessary skills for a variety of reasons. First, teachers face competing tasks, leaving little time to explore and experiment with AT and UDL implementation (Licwinko, 2024; Messinger-Willman & Marino, 2010; Schaaf, 2018). Messenger-Willman and Marino (2010) further emphasize this point, suggesting that AT professional development attempts to include too much information in a short period of time, making new information unpalatable or unmemorable. As the literature reveals, in-service training should focus on the implementation of AT devices and solving real-world problems for existing students in their classrooms, preferably in a one-on-one or workshop setting (Alsolami, 2022; Messinger-Willman & Marino, 2010).

From Training to Practice: How Perceptions, Confidence, and Competence Influence AT Implementation

Despite the well-documented gaps in the literature regarding AT training, many educators remain optimistic about future learning opportunities and implementation. Overwhelming evidence in the research suggests that, while AT competencies may be low, teachers maintained a

stance of high interest, and held overall positive perceptions of AT, understanding the benefits that AT affords students (Alsolami, 2022; Atanga, 2020; Lamond & Cunningham, 2020; Lamond et al., 2023; Licwinko, 2024; Park & Manning, 2023; Park et al., 2022). Similarly, special education co-teachers, consistently outlined in previous studies, reported having positive feelings related to technology usage (Licwinko, 2024). Additionally, confidence was found to be closely linked to familiarity and perceived usefulness, which is influenced heavily by adequate training and ongoing support (Lamond et al., 2023; Lamond & Cunningham, 2020).

These findings are promising, particularly given that increased AT knowledge has been shown to directly influence how useful educators perceive AT to be and that teacher attitudes and comfort levels directly correlate to its adoption in schools (Alkahtani, 2013; Lamond et al., 2023; Lamond & Cunningham, 2020). Further, research supports that when training supports ease of use, practical applications and provides sufficient time for learning, educators are more likely to develop positive associations, thus creating a higher likelihood of implementation (Atanga, 2020). Comfortability, too, extends further than mere implementation. Educator comfort with AT influences their ability to appropriately instruct students and is a key factor impacting whether students who were assigned AT would actually use these tools (Koch, 2017; Lamond & Cunningham, 2020; Zapf et al. 2016).

Positive outcomes are also supported by the finding that teacher competence directly predicts student use of AT (Atanga, 2020; Van Laarhoven et al., 2012). Alternatively, low AT competencies are among the factors that inhibit its use due to uncertainty surrounding AT determination and unfamiliarity with AT services (Park & Manning, 2023). While training is often seen as the solution, a perceived lack of AT knowledge remains a barrier even after training, suggesting potential shortcomings in the training itself (Lamond et al., 2023; Lamond &

Cunningham, 2020). Further, despite teachers' willingness to participate in school and district-provided training sessions, the timing of these sessions impedes their ability to do so (Licwinko, 2024).

Despite general positive attitudes towards AT and its implementation, not all teachers remain enthusiastic. For example, one study found that over half of all participants maintained a *neutral* attitude toward using AT in inclusive classrooms (Alkahtani, 2013); this amplifies the need to provide educators with effective training as a way to shift these perceptions and thus increase AT adoption. Ultimately, this openness provides a promising foundation for improvements for eventual widespread AT adoption, with teacher perceptions mediating the path toward meaningful and sustained integration.

Conclusion and Recommendations

This literature review explored how assistive technology (AT), particularly that which is embedded in universally accessible educational technology, can support all learners in the modern inclusive classroom, exploring the conditions necessary for effective and sustained adoption. Given modern technological advancements, AT is more accessible than ever before, even surfacing in embedded mainstream software such as Microsoft and Apple. Its accessibility, too, extends beyond tangible reach, aligning with Universal Design for Learning (UDL) principles and enabling flexible and palatable education for all. Despite its growing importance and with evidence suggesting a transition to being a staple for the classroom in a much broader context, inconsistencies remain regarding both preservice and in-service training, thus negatively impacting teacher perceptions, knowledge and confidence necessary for effective implementation. Institutional training and professional development are insufficient in and of themselves to bridge the gap towards ongoing and meaningful classroom adoption; traditional

models (i.e. unfocused one-off workshops) have proven ineffective. There is a vagueness and repetitive call to action in the literature to direct focus to more professional development and institutional coursework pre-graduation. However, an extensive review of the literature on the topic reveals that the mere quantity of training is unlikely to be the issue. Rather, there should be a focus on which models are proven successful while also strongly considering creative new approaches to the teachings of AT in education, especially considering the rapid developments of this technology – new technology calls for new, or at least empirically validated, approaches. The following recommendations include both suggestions supported by existing academic literature and those that are intuitive and author-driven.

Collaborative Models for AT Implementation

Drelick et al. (2024) offer an emerging co-teaching model (One Teach–One Tech), both explicitly outlining a collaborative framework and implicitly inspiring a look at less-individualized approaches to AT implementation. This model prompts consideration of additional collaborative strategies within inclusive classrooms, including cross-role informational exchange between general and special education teachers (McLaren et al. 2006), as well as multigenerational mentorship, as possibilities for supporting sustained and effective AT integration (Drelick et al., 2024; Lamond & Cunningham, 2020; Zhou et al., 2012). This varied and colourful collaborative approach aims to rid of the compartmentalization shared by AT itself. With a broadening of AT utilization, educators should look to similarly broaden access to information supporting its use.

A Culture Shift: AT for All

The decompartmentalization of assistive technology must extend beyond roles and responsibilities; it must also challenge the long-standing notion that AT is a specialized tool

reserved only for students with documented disabilities. As EdTech continues to evolve and align increasingly with UDL standards, educators should consider a similar shift in approach in the acceptance of AT being a beneficial and necessary component of the modern inclusive classroom. While not all, many valuable assistive technologies are now more accessible than ever, with low-cost and "low-brow" functionalities on the rise. As so, a shift in school culture appears necessary in encouraging a universal uptake, with AT received as a foundational tool rather than simply an add-on.

Reimagining AT Education

While there is no question the literature has considered the specifics and nuances of both preservice and inservice training for as long as AT use has been sought within the classroom setting, it can be argued there is much to debate regarding its effectiveness, both in inspiring teacher attitudes and confidence but also in creating a competence that equips teachers with the skills to adopt and apply these technologies on a long-term basis (Lamond & Cunningham, 2020; Park & Manning, 2023; Van Laarhoven et al., 2012). Although education can now be uncovered in endless venues (i.e. YouTube, internet platforms, and both embedded and generative AI tools), formal education must still include intentional informational relay that suits the specific needs of educators. This includes abundant opportunities for real-world examples, hands-on learning, and exposure to accessible, embedded technologies that are relevant to the classroom context (Schaaf, 2018; Lamond & Cunningham, 2020; Jones et al., 2021).

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Appendix A

Study Authors (Date)	Goal of the study (Research questions)	Type of study (i.e., case study, qualitative, correlational, single-subject design etc.)	Participants	Results 1	Results 2	Results 3/Discussion	Discussion/ Conclusions
Abner & Lahm (2002).	Is the educational use of assistive technologies abundant and widespread or isolated and limited? What AT is currently used for students with visual impairments? What does current teacher training look like and how does that impact students?	Survey: Teachers of students with visual impairments in Kentucky	**Certified teachers** of students with visual impairments who were teaching or were **enrolled in certification programs** in Kentucky in 2000. 145 surveys output, 79 completed, **72 usable**	The most used computer technology for students: screen-enlargement programs (31.9%); standard, unadapted systems (27.7%); screen-reader programs (19.5%); switch interfaces (12.5%); refreshable braille displays (2%)	Teachers' technological knowledge and skills are significant factors in students' use.	Teachers identify the need for training, with current training not specific enough, limited to school technology coordinator - other avenues for training are in-service workshops (short-term and focused) and word-of-mouth	Technology is available to teachers, but there is inadequate support for use -calls for hands-on and **practical training** -call for long-term and broader AT training

| Alnahdi (2014) | - Review the role and benefits of using assistive technology in the Universal Design for Learning (UDL), in academic skills, and in transition services.
- Review of principles that need to be considered in the integration of technology in educating students with disabilities | Literature Review | | Assistive technology is essential in the application of a **UDL** instructional design and, in return, Universal Design for Learning (UDL) provides accessible Curriculum Content, helping to raise the value of Assistive Technology | Technology (AT) plays an important and significant role in helping **students with disabilities** overcome academic difficulties as well as developing their academic skills | **Barriers:**
-teachers' reluctance to use (lack of teacher training, both pre- and in-service)

Recommendation:
-important that technology is included in preparation programs for special education teachers
-technology should be used as part of the preparatory program for teachers and cover technical applications at the classroom level | **Implementation looks like:**
1) Prioritize low-tech tools as the first option for AT
2) Explore existing mainstream tools before investing in specialized ed tech (costly)
3) Cost does not determine effectiveness
-choose AT based on the student's needs/ skills.
4) Adjustments to existing technologies can enhance accessibility |

Alsolami (2022)	1) What are the perceptions of special education teachers regarding their AT competencies? 2) Are these educators interested in training in AT? 3) What are the best methods for special education teachers to become familiar with AT?	Quantitative (survey)	64 special education teachers working for the Board of Education in Jeddah School District (Saudi Arabia)	-Most teachers of special education need PD on how to use AT successfully -Teachers reported a moderate level of skills and knowledge in using AT - lack of official training on AT	-Majority (90.6%) have a strong interest in gaining more knowledge and training	Preferred training options: 1) How: one-on-one training (50%), conferences/workshops (40%) 2) When: summer (39%), weekends (26%)	Comprehensive knowledge of AT enables teachers to create an appropriate learning environment that can accommodate all students, including those with disabilities -Integrate AT training into PD. -hands-on, personalized training -Develop structured training programs

Drelick et al., (2024)	1) What is One teach-one tech? 2) How can this strategy be implemented? 3) What are the barriers and challenges to implementation?	Strategy proposal	N/A	Co-teaching strategy one teach-one tech allows co-teaching partners to integrate technology into everyday lessons more seamlessly by clearly delegating technology-based responsibilities during planning, teaching, and assessment	Can be used with any of the co-teaching models, supports more successful technology integration and provides more structure t -can be implemented to support **intentional** technology integration ****Early career teachers can share their digital expertise with veteran teachers, promoting a culture of continuous learning and collaboration**	**Barriers:** -Limited planning and preparation time -Teacher confidence and familiarity with technology, particularly AT -Lack of structured professional development focusing on co-teaching and technology integration	One teach-one tech enhances technology integration, accessibility, and engagement - -opportunities for teacher collaboration and mutual learning (ed tech and AT)

| Fernández-Batanero et al. (2022) | A systematic review of studies pertaining to the impact of Assistive Technology (AT) for the inclusion of students with disabilities: 1) assess the overall state of AT research to improve the inclusion of students with disabilities. 2) to investigate the themes and future lines of research in this field
Q1. What are the trends in scientific production on assistive technology for students with disabilities in the field of education?
Q2. What are the findings on the use of Assistive Technology for students with disabilities between 2009 and 2020 in education?
Q3. What are the limitations on the application of Assistive Technology among stu- dents with disabilities in | Systematic review | 31 articles published between 2009 and 2020 | **Benefits** of AT use: inclusion and accessibility to school, improved teaching-learning process, allow student autonomy and independence, acquisition of social skills, participation and motivation | **Difficulties** in the use of AT: teachers' education, economic factors, tools access, details of the technologies themselves | **Common Research Focus** (clusters): 1) AT as an enabler of inclusion, 2) barriers to effective AT use, 3) benefits of AT - considering findings and common research topics, there is a push to explore solutions (e.g. teacher training programs) | -Barriers such as funding and lack of teacher training persist
-Training programs are essential for effective AT use
-Future research should explore the impact of AI-driven tools and teacher training strategies
-Most practical insights come from qualitative studies (teacher perceptions and student engagement) |

	education? Q4. What are the main lines of research in this field according to the keywords of the reviewed papers in the field of education?						

Jones et al., (2020)	Questions: 1. How do Pre-Service Teachers (PST) report they would go about selecting appropriate AT prior to instruction? 2. Does exposure to technology in the AT lab increase the number of devices/software/hardware that participants can list per area of need? 3. Does training in the SETT framework improve PST ability to apply the SETT framework correctly? 4. Do PST AT recommendations change as a result of exposure to technology any training in the SETT framework?	Pre-survey, stimulus/experiment, post-survey	68 participants, only 7 reported prior experience with AT	PSTs are better able to select and use appropriate AT devices. - directly related to the training provided (specifically SETT—Student, Environment, Tasks, Tools— framework training)	This study exemplifies the importance of teacher preparation programs ensuring that all education majors (general and special education) understand the distinctions between the vast variety of AT and how AT increases functional skills, increases access options, and embeds accommodations within the classroom	Post-survey, PSTs reported greater understanding of the importance of aligning AT selection with student needs, IEP goals, and environmental factors	PST perform AT selection with greater success when they have access to and receive appropriate training (SETT, access to IEP and other important information). -teacher training is vital in promoting teacher (specifically PST) readiness.

Lamond et al., (2023)	Understanding of the challenges with implementation of AT (teachers' perceived usefulness) 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 classroom	Mixed Methods -including a survey consisting of open- and closed-ended items	111 Grade 6–10 Ontario-certified teacher	-AT *knowledge* and access to resources significantly *predicted* perceived usefulness -AT *training* did *not* significantly predict perceived usefulness	-teachers with higher AT knowledge perceived AT as more useful -importance of hands-on training and ongoing practice for acquiring this knowledge	Teachers felt that self-directed learning and hands-on practice were more effective than formal training	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

| Licwinko (2024) | What are the technology integration attitudes and practices of special education co-teachers? What are the lived experiences of special education co-teachers in integrating technology into the inclusion setting? In what ways does the qualitative interview data with special education teachers explain the quantitative data about their frequency of and attitudes toward technology integration in the inclusion setting? | "Explanatory Mixed Methods Study" | 300 special education co-teachers working within pre-kindergarten through twelfth-grade inclusion classrooms in public schools throughout the United States (46 states) | For the assistive technologies or accessibility features, text-to-speech, digital timer or focusing tools, word prediction software, proofreading tools, and speech-to-text were the most commonly used tools within the inclusion classroom. | Tech use focused on personalized work based on individual student needs, collaboration between peers, and engaging in self-paced work or activities. -more focused on accessibility and student support rather than direct content delivery. | **Barriers** -tech as a distractor in the classroom -lack of training -limited planning time -inconsistent access to devices/software. -tech used for all students, with applications to provide individualized, one-on-one support for students who need assistance remaining on task | -Special education co-teachers are interested in more timely and appropriate technology professional development -special education co-teachers are asynchronously co-planning with their partner - asynchronous, digital alternatives are used -special education co-teachers focus their technology integration on student needs over subject matter |

Ludlow (2014)	**Themes:** -increasing integration of AT into mainstream -AT benefits **all users**, not just individuals with disabilities. -what it means to have AT becoming a standard feature in everyday technology	Editorial	N/A	AT tools like speech-to-text and text-to-speech are widely used by all	Mainstream tech and educational tech (AI, virtual assistants, online educational applications) are increasingly adapted for accessibility	AT and general tech are becoming more integrated - speaks to benefits for **all**	The number of devices and applications increase, thus increasing access to a greater range of supports that are more powerful, lower in cost, and less noticeable
Park & Manning (2023)	Understand the effects of a modified technology course on preservice teachers' preparedness for and perceptions of AT in inclusive classrooms (including general education PST) Questions: 1. What are the effects of the modified technology course on pre-service teachers' *perceived knowledge*? 2. What are the effects of the modified	Pre-survey, stimulus/experiment, post-survey	201 students were enrolled across eight sections	After receiving the modified technology course, PSTs showed statistically significant improvement in their AT competence, confidence, preparedness and a positive shift regarding inclusion	PSTs' perspectives toward AT showed little or no difference even after completing the modified technology course-attitudes positive both before and after training	After receiving intensive preparation in the use of assistive technologies, preservice teachers reported more positive responses toward inclusion -support for brief introduction to AT instructional courses	The key to success for both teachers and students is in the training and knowledge of educators regarding the implementation of AT. Training should begin with teacher educators during their preservice education.

	technology course on pre-service teachers' *perspectives toward* AT?						

| Schaaf (2018) | -What barriers have been reported to the effective use of AT in the classroom? -What are the most critical barriers encountered by Florida ESE teachers? -How well do existing professional development (PD) courses help overcome barriers to implementing AT in the classroom? -How can a district's PD curriculum be improved to meet the needs of its teachers? | Case Study (Surveys) | 27 Exceptional Student Education (ESE) teachers (18 completed demographic survey, 9 completed all surveys) | Issues that impacted the teachers' ability to use AT: -Lack of experience using needed AT -Lack of knowledge of AT available in the marketplace -Lack of knowledge of AT available in school -Lack of resources to learn about AT -Lack of training on needed AT Malfunctions with AT -Uncertainty on which AT to use to support various students' needs -Unfamiliarity with how AT works to support students' needs | -policies surrounding withholding of information on AT due to inability to provide new AT in school (lack of funding) -speaks to the indirect effect of funding on in-service AT education **-top two limitations**, malfunctions with AT and lack of training on needed AT **Professional Development(PD):** PD did not sufficiently cover: -Analysis of AT options to support students -categorizing errors with AT and apply appropriate corrective actions -choosing alternatives if AT is not working | Insufficient PD, teacher dependence on staff, and limited preservice AT exposure -hands-on practice and lending libraries are important in providing support | -Development of additional PD courses (for low-, mid-, and high-tech AT) will provide teachers with required knowledge and experience and increase their confidence -teachers must be prepared when AT devices fail to work properly -teachers must be able to correct issues with existing AT to free up the school staff |

| Van Laarhoven et al., (2012). | -What training positively impacts sustained faculty integration of AT in preservice programs? -what are the barriers surrounding long-term implementation of AT in preservice programs? | Case Study (Multi-year - 10 years) | Faculty and preservice educators in special education and general education programs in a large, state university in Illinois | Faculty reception to co-teaching preservice training was good, long term shift was unworkable - project staff were not able to shift responsibility for teaching AT to primary course instructors. Expertise and comfort with AT did not increase | -Faculty reception to full-day workshop was also good, but only few (11%) of faculty continued to implement learned AT into coursework independently

-5-day workshops were effective at increasing faculty members' familiarity, comfort level, and perceived effectiveness with using AT, but did not show long term success in independent and long-term AT implementation | -Video tutorials: most effective, sustained independent AT implementation -repeated exposure and hands-on experiences =greater confidence in integrating AT into coursework -**Barriers** to integration:lack of expertise, limited resources, thought that AT is only for certain students | -A change in attitude and disposition did not produce a change in actual practice -Ongoing support and PD important for ongoing AT use -AT training should be embedded across teacher education -Video tutorials and hands-on experiences improve faculty confidence/AT integration. |