

Assistive Technology

Outcomes and Benefits

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Looking Back and Moving Forward: 20 Years of Assistive Technology
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Editor-in-Chief



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Assistive Technology Outcomes and Benefits Looking Back and Moving Forward: 20 Years of ATOB

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Looking Back and Moving Forward: 20 Years of ATOB

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Assistive Technology Outcomes and Benefits

Editorial Policy

Aim and Scope

Assistive Technology Outcomes and Benefits, published by the Assistive Technology Industry Association, is an open access, peer-reviewed journal that publishes articles specifically addressing the benefits and outcomes of assistive technology (AT) for Persons with Disabilities across the lifespan. The journal's purpose is to advance the AT industry by (a) fostering communication among stakeholders interested in the field of AT, including manufacturers, vendors, practitioners, policy makers, researchers, consumers with disabilities, and family members; (b) facilitating evidence-based demonstrations and case-based dialogue regarding effective AT devices and services; and (c) helping stakeholders advocate for effective AT devices and services.

Assistive Technology Outcomes and Benefits invites for consideration submissions of original papers, reports and manuscripts that address outcomes and benefits related to AT devices and services. These may include (a) findings of original scientific research, including group studies and single subject designs; (b) qualitative and mixed methods studies, such as focus group and structured interview findings with consumers and their families regarding AT service delivery and associated outcomes and benefits; (c) marketing research related to AT demographics or devices and services; (d) technical notes and usability studies regarding AT product development findings; (e) project/program descriptions in which AT outcomes and benefits have been documented; (f) case-based reports on successful approaches to service delivery; and (g) consumer perspectives on AT devices and services.

Submission Categories

ATOB welcomes scholarly contributions. However, many stakeholders engaged in the field of AT do not have an academic background. ATOB offers a unique opportunity for these stakeholders to contribute their expertise and experience in the context of achieving successful outcomes and beneficial impacts. ATOB understands that many potential authors may lack experience in authoring papers for peer-reviewed journal publication. Therefore, the ATOB Editorial Board is pleased to offer assistance in preparing and refining relevant submissions. Articles may be submitted under three categories:

Voices from the Field

Articles submitted under this category should come from professionals who are involved in some aspect of AT service delivery with persons having disabilities, or from family members and/or consumers with disabilities. Submissions may include case studies, project or program descriptions, approaches to service delivery, or consumer perspective pieces. All submissions should have a clear message and be written with enough detail to allow replication of results. See [ATOB Editorial Policy](#) for more details.

Voices from Industry

Articles submitted under this category should come from professionals involved in developing and marketing specific AT devices and services. Case studies, design, marketing research, or project/program descriptions are appropriate for this category. See [ATOB Editorial Policy](#) for more details.

Voices from Academia

Articles submitted under this category should come from professionals conducting research or development in an academic setting. Submissions are likely to include applied/clinical research, case studies, and project/program descriptions. See [ATOB Editorial Policy](#) for more details.

Types of Articles

Within each of the voices categories, authors have some latitude regarding the type of manuscript submitted and content to be included. However, ATOB will only accept original material that has not been published elsewhere and is not currently under review by other publishers. Additionally, all manuscripts should offer sufficient detail to allow for replication of the described work.

Applied/Clinical Research: This category includes original work presented with careful attention to research design, objective data analysis, and reference to the literature.

Case Studies: This category includes studies that involve only one or a few subjects or an informal protocol.

Design: This category includes descriptions of conceptual or physical design of new AT models or devices.

Marketing Research: This category includes industry-based research related to specific AT devices and/or services, demographic reports, and identification of AT trends and future projections.

Project/Program Description: This category includes descriptions of grant projects, private foundation activities, institutes, and centers having specific goals and objectives related to AT outcomes and benefits.

Approaches to Service Delivery: This category includes descriptions of the application of assistive technology in any setting (educational, vocational, home-life) to improve quality of life for people with disabilities.

Consumer and Caregiver Perspectives: This category offers an opportunity for product end users, family members, and caregivers to share their experiences in achieving successful outcomes and benefits through the application or use of AT devices and services.

Mandatory Components of All Articles

Authors must include a section titled Outcomes and Benefits containing a discussion related to outcomes and benefits of the AT devices/services addressed in the article. Authors must include a short description of the article's target audience and indicate the article's relevance to that target audience.

Publishing Guidelines

Review detailed [Manuscript Preparation for Authors](#) for information on formatting requirements and submission guidelines.

For More Information

Please see [ATOB's Editorial Policy](#) for more details regarding the submission and review process, ATOB's Copyright Policy, and ATOB's Publication Ethics and Malpractice Statement.

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Introduction to Volume 18

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Looking Back and Moving Forward: 20 Years of Assistive Technology Outcomes and Benefits

Assistive Technology Outcomes & Benefits journal (ATOB) was launched by the Assistive Technology Industry Association in 2004 in an effort to advance the AT field and highlight new information on the outcomes and benefits of assistive technology for persons with disabilities. ATOB is a leading, open access, peer-reviewed journal in the field of AT. Unique to ATOB, the journal provides a dissemination platform to various AT stakeholders. In addition to traditional scholarly contributions, ATOB publishes the experiences of AT practitioners and AT users. Thus, manuscripts may be submitted under three categories: Voices from the Field, Voices from the Industry, and Voices from Academia. In almost 20 years since its inception, ATOB has published different voices across many different topics. Articles focused on specific types of AT (e.g., for Autism Spectrum Disorders, for literacy, for communication) as well as on overarching processes (e.g.,

technology transfer, research and development, personnel preparation, AT services during the pandemic; see [ATOB Archives](#)).

Volume 18 commemorates ATOB's 20th anniversary, and it is representative of ATOB's mission. It includes all three categories of articles published by ATOB: Voices from Academia (Bell et al.; McDonnall et al.; Smith et al.; Tucker; Veenendall et al.), Voices from the Industry (Banes et al.; Hackbarth), and Voices from the Field (McIndoe et al.; Reed et al.; Shea et al.). Voices from Academia share the results of large implementation studies (e.g., Smith et al.) as well as preliminary explorations (e.g., Veenendall et al.). The studies utilize qualitative (e.g., Tucker) and quantitative survey methods (e.g., McDonnall et al.). Manuscripts in the Voices from the Industry category look back at the evolution of mobile technology (e.g., Banes et al.) as well as move us forward discussing emerging AI technology (e.g., Hackbarth). Voices from the Field highlight perspectives of individuals with disabilities (e.g., Shea et al.) as well as AT providers working directly with those individuals (e.g., McIndoe et al.). Articles represent experiences and viewpoints from the U.S. (e.g., Reed et al.) as well as from international professionals (e.g., Bell et al.).

Voices from Academia

In the first article in the Voices from Academia category, *Developing a Holistic Process to Measure Assistive Technology Outcomes*, Diane Bell and colleagues emphasize the urgent need for a global standard in measuring outcomes of assistive technology (AT) interventions. It is imperative given the complexity of both AT devices and services as well as the diversity of stakeholders involved. Challenges in documenting AT outcomes include the varied methodologies used across different contexts and the need for innovation in research. The authors used the 5P model (people, products, personnel, provision, and policy) as a framework for reviewing the existing literature and understanding AT outcomes. They propose a new process to collect and analyze data on AT outcomes aligned with the 5P model. The result is a roadmap for stakeholders, from users through policy makers, to guide the future of research and policy, emphasizing the need for collaboration to enhance AT access and use globally.

In their study, *Actual and Preferred Methods for Learning to Use Assistive Technology*, Michele McDonnall, Anne Steverson, and Jamie Boydston have investigated the learning preferences of individuals who are blind or have low vision. While most participants identified self-training as the actual learning method, more formal hands-on training was the preferred method for learning to use new AT. This study guides AT service providers in designing the best training for this specific audience. The formal training opportunities should utilize mobile apps, develop problem-solving skills, and incorporate opportunities to locate and use training resources available online. The ongoing, lifelong learning is crucial as user needs, environments, and technology tools change constantly.

Sean Smith and colleagues discuss the Writing Classroom initiative in their article *Integrating Assistive Technology into the Writing Process*. This initiative is a federally funded project aimed at enhancing writing outcomes for middle school students with disabilities by integrating AT tools into effective writing strategies. Central to this initiative is the WRITE progress monitoring tool, a web-based system providing auto-scored short-writes based on Curriculum-Based Measures. WRITE offers writing prompts across different genres and scores student work on spelling accuracy, word count, and sequencing. The Writing Classroom also includes instructional modules with videos and guides for educators to address common writing challenges using AT tools. The authors emphasize the importance of writing in demonstrating student learning and how students with disabilities often require explicit writing instruction, dedicated writing time, established routines,

and regular feedback. The integration of these strategies for instruction, enhanced with proven AT tools, is shown to improve the writing outcomes for these students.

The article *Impacts of an Assistive Technology Graduate Program: A Case Study* by Lauren Tucker examines the impact of one AT graduate program on the professional practices of educators and service providers. Through surveys and focus groups with alumni across seven years, the study reveals that the graduates of this AT program demonstrate increased confidence and skill in implementing technology in their careers. Additionally, it explores the application of Kolb's Experiential Learning Theory in analyzing the learning experiences within such a program. Overall, the article emphasizes the importance of integrating AT-specific coursework into graduate programs to enhance professional practice and improve outcomes for individuals with disabilities.

The exploratory feasibility study was conducted by Jennifer Veenendall, Shirley O'Brien, and Julie Duckart and presented in the article *Assistive Technology Training in Transition Programming*. It included three special educators in a midwestern city's tri-district secondary transition program for individuals with disabilities aged 18–21. The study explored the perceived impact of AT training on participants' experiences in AT consideration, AT evaluation, team AT collaboration, and AT documentation in IEPs. Based on pre- and post-training surveys, professional development sessions focused on SETT Framework, and Quality Indicators for Assistive Technology resulted in increased confidence, particularly in AT consideration. However, AT documentation practices remained unchanged. Despite limitations such as a small sample size and potential confounding variables, this preliminary qualitative study provides valuable insights for enhancing AT services in transition programs, with implications for improving vocational outcomes and overall well-being for young adults with disabilities.

Voices from the Industry

Both articles in the Voices from the Industry category are thought provoking. David Banes, Sabine Lobnig, and Michael Milligan discuss the evolution of mobile technology and its impact on accessibility for individuals with disabilities. It highlights significant milestones from the early mobile phone era in the 1970s to the rise of smartphones, noting how legislative changes and stakeholder engagement contributed to greater inclusion. The development of touchscreen smartphones in 2007 revolutionized accessibility, integrating features like text-to-speech, dictation, and digital assistants. The Global Accessibility Reporting Initiative (GARI) database, founded in 2008, serves as a resource on mobile accessibility features. Its review makes it obvious that changes in mobile phone capabilities blurred the lines between assistive and mainstream technologies, making a significant impact on the lives of people with disabilities. This evolution process can be used to guide future developments of innovative technologies. Over the past decade, the design of products that empower people with a disability has shifted from specialized and dedicated products designed only for those with a disability to features and functions integrated into cost-effective consumer technologies for the benefit of all.

Ken Hackbarth speculates on the rapidly approaching revolution in Augmentative and Alternative Communication (AAC) due to the developments in generative AI. He suggests that we "...are on the verge of a disruptive revolution that will reshape most aspects of life and open doors for AAC users that have been, until now, largely closed." The new generation of AI-powered AAC devices will enable real-time conversations for individuals with complex communication needs based on the contextual prompts. In addition, advancements in text-to-speech, facial recognition, and eye tracking capabilities may transform AAC devices,

making them more intuitive and personalized. The author urges the AAC companies, users, service providers, and researchers to adapt quickly, comparing it to transformations seen in the camera industry with the advent of digital imaging. It is imperative to start integrating the existing and emerging technologies to enhance the AAC industry.

Voices from the Field

Coleen McIndoe and Aftynne Cheek kick off the Voices from the Field category with their article *Shared Reading with Core Vocabulary: Creating Interactive Experiences at Home*. Their article discusses the importance of supporting meaningful communication and literacy experiences for students of all ages with significant cognitive disabilities and complex communication needs. The authors share a field-based example of how access to parent training and a core vocabulary board supported a mother to actively engage with her adolescent daughter using shared reading practices aimed at promoting communication and increasing language use. The example demonstrates the potential for parents and caregivers to successfully implement augmentative communication with core vocabulary and shared reading when provided access to appropriate resources. Resources like Project Core and Tar Heel Reader allow parents to not only access materials needed to teach their children, but also provide instructional material for parents to learn how to do it themselves at home.

The article *Quality Indicators for Assistive Technology—How an Idea Grew* presented by Dr. Penny Reed and the whole QIAT leadership team describes the evolution of the AT field with its challenges in systematic and consistent AT service delivery in schools leading to the development of the Quality Indicators for Assistive Technology (QIAT). QIAT initiative, which is grounded in collaboration and contributions from hundreds of service providers, outlines essential elements for effective AT services and provides self-evaluation matrices for continuous improvement. The article underscores the importance of QIAT for educators, families, policymakers, and students with disabilities, as it offers a framework for evaluating and enhancing AT services. As we look forward, QIAT plans to expand its scope to other educational settings and high-stakes assessments, maintaining its focus on collaborative decision-making and multiple perspectives.

Project Achieve, highlighted in Jan Shea's, Kelly Ligon's, and Katherine Martinez's Voices from the Field article, *How Far We've Come: How Assistive Technology Changed the Game*, was a transformative three-year initiative aimed at empowering women veteran students with traumatic brain injury (TBI) through the use of AT in higher education. The program provided personalized technological tools such as iPads and targeted apps, alongside individualized support from Technology and Employment Counselors (TECs). This approach proved to be a "game changer" for participants like Katherine, a Latina woman veteran who, through the project, was able to overcome significant learning challenges induced by TBI, achieve academic success, and realize her professional potential. The article highlights the critical gap in support services for women veterans in higher education, emphasizing the need for increased collaboration among various campus services and the adoption of universal design principles to foster inclusive environments. Additionally, the article underscores the power of partnership between clients and service providers. Katherine was coached by her TECs to have an ongoing "voice and a choice" in the selection and use of her AT, which resulted in a personalized response to her needs and empowered her to advocate for increased student access to AT at the university she attended. As Katherine stated, "I now know there is room to start conversations with other institutions to adopt something similar in their accessibility office, [for] employers to be more mindful of accommodations for their employees that live with TBI, and [to] bring attention to how assistive technology can aid in your everyday life."

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Voices from Academia

Developing a Holistic Process to Measure Assistive Technology Outcomes

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Abstract

Assistive technology (AT) outcomes research sits across different fields of practice and uses, diverse measures and methodologies. Instruments have been developed to measure AT outcomes, but data are not routinely collected nor published in most settings. This impedes the evaluation and development of policy in

the field and prevents the sharing of best practices across settings and countries. Aiming to summarize existing knowledge about assistive technology outcomes and propose directions for the future, we provide a broad narrative synthesis of existing literature about AT outcomes conceptualized through the people-centered 5P model of the WHO Global Cooperation on Assistive Technology initiative and the GAATO Assistive Technology Outcomes and Impacts Model. We conclude that the 5P system model operates as a viable, integrative framework which supports a holistic understanding of the challenges associated with measuring AT outcomes. The development of a process to measure AT outcomes is proposed.

Keywords: assistive technology, outcomes, 5P model, measurement

Developing a Holistic Process to Measure Assistive Technology Outcomes Context, Challenges and Complexities of Assistive Technology

The pressing need for evidence to support the complex and growing interventions in the field of assistive technology (AT) has long been articulated (DeRuyter, 1995, 1997; Scherer, 1996a, 1996b) and has become more urgent in the current context of the physical, digital and biological realms that are being merged through rapidly developing technology (Scherer et al., 2019). Every stakeholder within the AT industry has a need to see outcomes achieved, especially the users of AT and their families (Smith, 2021). There is a need for a common understanding of what these outcomes are, who defines them and how they are measured, so that the results can be compared.

The definition of outcomes depends on what stakeholder is being addressed. Clinicians may focus on an individual's functional gain, while clinic directors have their eye on cost containment and profit. Consumers are most interested in enhanced capabilities and well-being (Fuhrer et al., 2003; Jutai et al., 2005; Lenker et al., 2005; Scherer & Galvin, 1996; Scherer & Smith, 2021). While a good deal of emphasis today is on measures of specific outcomes with particular products or functional goals, the purpose of this paper is to discuss a more broad and global perspective.

To effectively compare outcomes, we must use a common understanding of what assistive technology is. The World Health Organization (WHO) defines assistive technology as the "application of organized knowledge and skills related to assistive products, including systems and services." Assistive products are further defined as "any external product (including devices, equipment, instruments or software), specially produced or generally available, the primary purpose of which is to maintain or improve an individual's functioning and independence, and thereby promote their well-being. Assistive products are also used to prevent impairments and secondary health conditions" (WHO, 2016). Assistive products are also defined by the International Organization of Standardization (ISO) as "any product (including devices, equipment, instruments and software), specially produced or generally available, used by or for persons with disability for participation; to protect, support, train, measure or substitute for body functions/structures and activities; or to prevent impairments, activity limitations or participation restrictions" (ISO, 2016). When considering outcomes, and how we measure them, we must therefore consider outcomes associated not only with the assistive products themselves, but also those associated with the broader systems and services used to deliver them to the people who need them. The WHO has identified 5 interrelated concepts which impact the delivery of assistive

products: people (the users of assistive products), products, personnel, provision, and policy. These are collectively known as the WHO-GATE 5P model (WHO, 2020) and will be referred to throughout this work.

The Global Alliance of Assistive Technology Organizations (GAATO) propose that “measuring outcomes and impact is necessary to understand the benefits of assistive technology and create evidence-based policies and systems to ensure universal access to it” (GAATO, 2022a). However, the proposal embodies several challenges to achieving this goal, such as the measurement of AT outcomes and impact at individual, community, local, national, and global levels; instruments for data collection and use; outcomes related to systems and their implementation; and the evaluation of good practices and policies (GAATO, 2022a).

Defining the outcomes of assistive technology interventions is complex, not least of all because of the current rate and scope of technological innovation. Firstly, it is essential to know what specific interventions are being examined and what outcomes to measure. Secondly, what Smith (2002, p. 240) described as “InGo”, must be clearly identified. However, specifying the variables that “go in” to the intervention to enable an “outcome” is challenging because AT systems are complex, personalized and highly diverse across population distributions (Smith, 2016). Thirdly, context is critical because AT is rarely used in isolation. Therefore, comprehending and managing simultaneous and analogous interventions is essential in order to examine the effectiveness of AT (Smith, 2005). Finally, multiple stakeholders are involved in the provision and use of AT and are likely to view outcomes from specific perspectives (Layton et al., 2020; Rist et al., 2008; Scherer, 2020).

The complexities discussed above are the result of a set of variables that are dependent on dynamic, interrelated factors in the environment or context, which indicates that, unless comprehended and managed, the general use and measurement of AT outcomes occurs in an open system. Recent conceptual thinking about assistive technology is that although assistive products can be thought of as a closed system where variables can be controlled and results or outcomes can be replicated, it is best to view service provision as an integral part of the AT bundle provided (MacLachlan et al., 2018). We argue in this paper that what is needed is not to view separate components as open or closed systems but to adopt a holistic view to develop a process that can be used to measure all critical aspects of AT systems and their outcomes.

Purpose Statement

The objective of this paper is to kickstart development of a process that could be used globally to measure the outcomes of AT interventions. We accomplish this by first summarizing the research experience of key authors and networks of contributors. This broad pool of expertise is synthesized into a commentary connecting two contemporary models: the WHO-GATE 5P framework for strengthening access to AT (WHO, 2020), and the Global Alliance of Assistive Technology Organizations Outcomes and Impacts Model (GAATO, 2022b).

Target Audience and Relevance

Given the diversity of stakeholders in the AT ecosystem, the *Assistive Technology Outcomes and Benefits (ATOBS)* audience are essential players, part of developing a holistic process to measure assistive technology outcomes. More specifically, the stakeholders that could benefit most from this article include assistive technology providers, suppliers, manufacturers and developers, as well as consumers.

Methods

In order to achieve the primary objective of this paper, i.e., to contribute to the development of a process that could be used globally to measure the outcomes of AT interventions, the following steps were completed. Firstly, the state of science related to global AT outcomes and impact was summarized. Secondly, gaps in the 5Ps were identified by mapping existing data, frameworks, and techniques to the goals of the outcomes of the AT system. Thirdly, current outcome conceptions were identified and critically evaluated in the light of their potential use in various contexts, including high- and lower-middle-income countries. Finally, a model for a holistic understanding of AT outcomes was developed based on the 5P model and in the context of the GAATO AT Outcomes and Impacts Model.

Results

Summary of Existing Body of Knowledge on AT Outcomes

Major AT outcomes and research instruments over a number of decades were identified and summarized (Table 1). The examples in Table 1 represent the most cited and frequently mentioned technology-focused outcomes measures. The mid-1990s were the heyday of developments in AT outcomes (e.g., DeRuyter, 1995; Scherer, 1996a, 1996b; Scherer & Galvin, 1996), both theoretically and as the measures presented in Table 1 indicate, in the development of tools to measure outcomes. The tools were, for the most part, designed to be used across disability types, ages, and assistive products.

Table 1: Measuring Particular Outcomes: Examples of Available and Validated Technology-focused Instruments

OUTCOME	MEASURE/ APPROACH	FOCUS	FIELD OF RESEARCH / DISCIPLINE FROM WHICH MEASURES WERE DEVELOPED
Intention to use	UTAUT, TAM (Davis et al., 1989; Venkatesh et al., 2003)	Product <ul style="list-style-type: none"> Perceived usefulness and ease of use 	Business/Commerce; Information Technology
Expectations of benefit from use	MPT measures/ATD PA initial (Scherer & Craddock, 2002; Scherer & McKee, 1990)	Person and Provision <ul style="list-style-type: none"> Motivation, readiness, subjective need, personal factors 	Behavioral science
Goal attainment	IPPA (Wessels et al., 2002)	Provision <ul style="list-style-type: none"> Goal identification and attainment 	Health sciences; Education
Satisfaction with Product and Service delivery	QUEST (Demers et al., 2002)	Product and Provision <ul style="list-style-type: none"> Device features, service delivery, usability 	Occupational therapy; Education
Realization of benefit from use	ATD PA follow-up (Scherer & Glueckauf, 2005)	Person and Provision <ul style="list-style-type: none"> Person-Product Match Performance Use worthiness 	Behavioral science

OUTCOME	MEASURE/ APPROACH	FOCUS	FIELD OF RESEARCH / DISCIPLINE FROM WHICH MEASURES WERE DEVELOPED
Psychosocial Impact	PIADS (Jutai & Day, 2002), MPT measures	Person <ul style="list-style-type: none"> Competence, adaptability, self-esteem 	Psychology
Functional Performance	OTFACT (R. O. Smith, 2002)	Person <ul style="list-style-type: none"> Function with and without the use of assistive technology 	Occupational therapy

(Scherer et al., 2019)

Abbreviations

ATD PA = Assistive Technology Device Predisposition Assessment

IPPA = Individually Prioritized Problem Assessment

MPT = Matching Person and Technology

OTFACT = OT Functional Assessment Compilation Tool

PIADS = Psychosocial Impact of Assistive Devices Scale

QUEST = Quebec User Evaluation of Satisfaction with Assistive Technology

TAM = Technology Acceptance Model

UTAUT = The unified theory of acceptance and use of technology

When two centers to study assistive technology outcomes were funded in 2001 by the U.S. National Institute for Disability and Rehabilitation Research, much of the focus through the early 2000s was on more general and conceptual contributions. Existing outcomes measures were reviewed in the context of meeting service provision needs. These instruments revealed a conundrum regarding the use of measurement tools that persists to this day. That is, instruments generally either measure contributing factors to AT outcomes or measure the effects of AT use (Fuhrer et al., 2003; Jutai et al., 2005; Lenker et al., 2005).

When *Assistive Technology Outcomes and Benefits* debuted in 2004, the issues reflected a blend of theoretical and practical. Starting in the mid-2010s, outcomes studies became more specific, focusing on a particular product or rehabilitation target (Bigras et al., 2020; Cruz et al., 2021; Subramanian et al., 2022). The literature demonstrated the importance of not only focusing on functional performance outcomes, but also recognizing underlying and alternate factors that might influence the use of AT, such as complexity of devices or lack of personnel training (Smith et al., 2018).

Recent global initiatives have once again brought conceptual issues to the forefront, but there has been little work in the development of additional outcomes measures unless designed for a specific population or purpose (Scherer et al., 2019; Scherer & Smith, 2021).

Contemporary Views Informing AT Outcomes

In the WHO/UNICEF Global Report on Assistive Technology (WHO & UNICEF, 2022) it was recognized that monitoring user outcomes is essential. Recommendation 6, *Invest in data and evidence-based policy*, called for “Outcomes in terms of human rights and quality of life for users, their families and the community or country” (p. 101).

This was closely related to Recommendation 8, *Develop and invest in enabling environments*, in which it was noted that, “The outcomes of assistive technology depend largely on the existence of enabling environments”

(p. 102). The recommendations and actions in the Global Report were operationalized according to the 5P Model shown in Figure 1.

Figure 1: WHO’s GATE 5P People-Centered Assistive Technology



Note: Source - ©2022, World Health Organization and UNICEF. Used with permission.

There are numerous stakeholders in this model, represented by the 5Ps: Policy, Products, Personnel and Provision, with the focus on People being central to the entire system (WHO, 2020). An expansion to 10 Ps was proposed in 2017, adding the concepts of Procurement, Place, Pace, Promotion and Partnership, which together “... constitute a framework ... that can evolve and adapt, that empowers users, inter-connects key components and located these in the reality of differing contexts” (MacLachlan & Scherer, 2018).

The 5Ps Model is used to frame AT outcomes and integrate the additional P concepts in the discussion in the section on *Differential desires for outcomes* below. Additionally, during a recent global consultation that comprised over 300 AT stakeholder perspectives from all WHO global regions, six key challenges related to AT outcomes and impacts globally were identified as shown in Figure 2 (GAATO, 2022c).

Figure 2: GAATO AT Outcomes and Impacts Model



Note: Source - ©2022, GAATO. Used with permission.

Implications of Context for AT Outcomes

Currently, in high-resourced settings, service delivery and implementation are prioritized with little mandate or commitment toward documentation and data collection. This may be driven by the notion that manufacturers and providers are responsible to generate the evidence to promote their products. For example, pharmaceutical companies that develop new drugs are responsible to run clinical trials and capture the evidence to obtain approvals from public regulators. This methodology works for large corporations but is not feasible for smaller companies such as those that support the AT industries.

Although WHO-GATE has activated the implementation of assistive technology programs globally, historically, little or no funding has been provided to new assistive technology programs to support outcomes documentation. Nevertheless, the emphasis on evidenced-based practice and person-centered service delivery has increased the significance of developing, utilizing, and disseminating systemic models for the outcomes of assistive technology (Scherer & Federici, 2018; Zapf, 2023). The requirement for evidence documentation to support the ongoing efficacy of assistive technology solutions is growing. It is argued that the idea of evidence-based funding will challenge and spread across the board for AT initiatives. Thus, for all populations of people who require assistive technology products and services, as well as the providers of those services, gathering evidence through reporting the outcomes of assistive technology will become crucial. Assistive technology programs must therefore take outcomes measurement systems for assistive technology into account. For example, in low-income settings, the development of information technology and the widespread use of mobile devices is enabling data collection regarding mobile-device related assistive technology outcomes to be captured (Savage et al., 2020). This is therefore an ideal time to incorporate outcomes documenting into programs for the provision of assistive technology. Leadership and/or partnership initiatives can support stakeholders within lower resourced settings to make this a reality (GSM Association, 2018; Holloway et al., 2018). Such initiatives can serve as fresh examples that demonstrate innovative and successful measurement of outcomes.

5Ps Differential Desires for Outcomes

In this section, AT outcomes are explored from the perspective of the WHO 5P, people-centered, assistive technology model. Which P is most related to each particular outcome measure is shown in Table 1.

Systems for assistive technology that are stand-alone or integrated contain connected components and dynamic processes. A simplified view of the assistive technology system is provided in Figure 1. According to this approach, the four inter-connected elements of the assistive technology system—products, provision, staff, and policy—determine how users experience the process for gaining access to assistive technology. Holistic solutions are more effective when all system components and their interactions are understood. Policy influences the range, quantity, quality, and cost of the items that are offered, including the design and implementation of the provision (procurement, delivery, and services), and the capability of the workforce (legislation, policy structures, information system, financing).

A discussion of the perspectives and influences of the 5Ps on the outcomes of the system follows, with examples of the questions that should be asked to obtain relevant data, and what should be documented. Each P is associated with unique stakeholders and leads to unique perspectives on the outcomes.

People (the User)

The perspectives of people who use assistive technology are central to our understanding of the need for and utility of assistive products themselves, as well as the experience of navigating assistive technology systems and policies (Desmond et al., 2018). In order for users to derive value from their AT, it must fulfil their requirements and be useful and valued, otherwise it might be abandoned and not used at all. This domain of outcomes includes subjective user perspectives, e.g. comfort, self-consciousness, etc. As a result, no single AT is likely to meet the needs of all the various stakeholders (see Table 2). Interestingly, consumers of assistive technology might not even perceive the term “outcomes” as a word of choice when they are interested in product utility (Lenker et al., 2013).

Table 2: Examples of the Influences Upon the System Related to People and How to Document Outcomes

Questions to examine influences on outcomes of the system	Documentation of statements of outcomes (examples of successful inclusion)
<p><i>Partnership</i></p> <ul style="list-style-type: none"> • What are the expectations of what will be gained from use of the device compared with what is currently being done or used? • What are the characteristics of others in the environments of use? Supportive, resistant, stigmatizing? • Are there cultural mores or beliefs that disavow use of the technology? • Has the need for additional supports and assistance been considered and are they available if needed? 	<ul style="list-style-type: none"> • Documentation of personal and contextual characteristics (functional needs, subjective needs, social and material support, personal preferences and priorities, well-being). • Identified expectations of benefit and follow-up documentation of the realization of benefit.

(Desmond et al., 2018 and Lenker et al., 2013)

Policy

The legislative, regulatory, structural, and environmental contexts of the other Ps are embraced by "Policy" (see Table 3) which serves to develop and record key outcomes such as laws or codes. As key role-players in the AT environment, policymakers have a vested interest in costs versus benefits (Scherer et al., 2019). Also, funders often play a role in establishing a need for outcomes documentation (Clayback et al., 2015). Further, there is an identified need to evaluate policy for its ability to contribute to the realization of human rights, and to enable equitable access to assistive technology (MacLachlan & Scherer, 2018).

Table 3: Examples of Influences on Outcomes of the System Related to Policy

Questions to examine influences on outcomes of the system	Documentation of statements of outcomes (examples of successful inclusion)
<p><i>Place</i></p> <ul style="list-style-type: none"> • Are all of the necessary architectural supports in place? • Is there adequate infrastructure for use? • Is there accessibility to equipment and facilities? • Is there adequate supply of electricity? • If assistance is required for student training and use of the technology, is it available? • Do classroom settings need to be re-organized? • Is there access to ancillary facilities, for example, classroom environments for training and learning? 	<ul style="list-style-type: none"> • Documentation of availability of facilities and accessibility to sufficient equipment, supplies, materials and other resources.
<p><i>Legislative/Political/Regulatory</i></p> <ul style="list-style-type: none"> • Are there mandated services? Is there licensure of providers? • Are relevant community resources needed and are they available? 	<ul style="list-style-type: none"> • Documentation of sufficient laws, regulations and codes. • Evidence of legal and regulatory compliance. • Evidence that products meet regulatory standards. • Proof that products have been safety-tested. • Documented guidelines for meeting and exceeding minimal requirements.
<p><i>Economic</i></p> <ul style="list-style-type: none"> • What are the costs of service provision? What are the training-related costs? • What are the costs for repairs and maintenance? • Is funding available for the products and services? • Can products be re-used, recycled? 	<ul style="list-style-type: none"> • Information about funding available for programs and facilities. • Information about funding available for products. • Information about funding available for services. • Documentation to show that the program is economically viable.

(Scherer et al., 2019; Clayback et al., 2015; and MacLachlan et al., 2018)

Provision

The provision of AT programs is usually an administrative outcome that frequently involves examining the process of service delivery and often might include evaluations, such as surveys, of the users’ satisfaction and realization of benefit from use (See Table 4). As previously mentioned, measuring outcomes depends on data collection, preferably post-intervention in addition to the baseline data. Provision also involves consideration of the composition of the AT team and how its members are incorporated into the services provided (Scherer et al., 2019). Previous research has identified the establishment of key quality indicators for assistive technology provision systems as key to decision-making for efficient and effective services (De Witte et al., 2018).

Table 4: Examples of Influences on Outcomes of the System Related to Provision

Questions to examine influences on outcomes of the system	Documentation of statements of outcomes (examples of successful inclusion)
<p><i>Selecting the technology or other support</i></p> <ul style="list-style-type: none"> • Has a comprehensive assessment been done to select what will best suit the user’s needs and preferences (a technology, additional personal assistance, a combination)? • Have options been prioritized, and has it been decided why one product or feature is preferable to another? • Has the technology been assembled correctly? • Has a trial been undertaken in the settings of use? 	<ul style="list-style-type: none"> • Directories of local facilities and resources are available. • A process to guide AT selection and decision-making is available and used. • Documentation that a comprehensive assessment was done. • There is a satisfactory balance sheet. • Proof that Products meet regulatory standards. • Evidence that products have been safety-tested. • There is a satisfactory safety record. • Formal partnerships exist between users, manufacturers, suppliers, and vendors. • Documentation of the results of consumer trials and locations of trials.

(Scherer et al., 2019 and De Witte et al., 2018)

Personnel

Individual experiences, viewpoints, and pre- and post-service training of AT personnel (including professionals and non-professional staff) all play a role in effective service delivery, i.e., delivering effective AT interventions. Key results, which are best captured using both qualitative and quantitative data, include adequate staffing (Scherer et al., 2019) and sustainability indicators (Smith et al., 2018; see Table 5). Assistive technology education and certification has been a focus for decades (Kanny et al., 1991) and remains an active and current area of concern (Goldberg et al., 2022).

Table 5: Examples of Influences on Outcomes of the System Related to Personnel

Questions to examine influences on outcomes of the system	Documentation of statements of outcomes (examples of successful inclusion)
<ul style="list-style-type: none"> • Have providers received adequate training? • Are regular training opportunities provided to provide new and updated information? • Do providers have the essential certification or licence? • Do providers have the resources and support they need? 	<ul style="list-style-type: none"> • Proof that providers meet all qualifications to practice. • Evidence of satisfactory provider performance. • Evidence of provider satisfaction.

(Scherer et al., 2019; Smith et al., 2018; Kenny et al., 1991; and Goldberg et al., 2022)

Products

The key role-players in this domain are the product designers (who focus on product appearance, costs, safety, usability, and mechanical aspects), manufacturers and suppliers. Thus, product outcomes refer

essentially to the technical characteristics (Scherer et al., 2019; see Table 6). It is critical that outcomes data which are relevant to all stakeholders in the product development and evaluation process be collected (Smith et al., 2018).

The key message from the 5Ps is that all are stakeholders' positions with unique contributions and interests pertaining to AT outcomes are important. Some Ps may have common interests between them, but often they are disparate. Consequently, considering all 5Ps is a necessary step in designing, creating, and implementing an AT outcomes system that ultimately successfully measures the impact of AT interventions (Scherer et al., 2019).

Table 6: Examples of Influences on Outcomes of the System Related to Products

Questions to examine influences on outcomes of the system	Outcome documentation statements (examples of successful inclusion)
<p><i>Performance</i></p> <ul style="list-style-type: none"> • Is the product reliable? • Is the product stigmatizing, fatiguing, painful to use? • Is the product compatible with use of other supports, durable, portable, easily serviceable? • Does the technology require customizing or other adaptations? 	<ul style="list-style-type: none"> • Evidence that available products are reliable are. • Evidence that products are publicly accepted. • Evidence of insights obtained from user experience (compatibility, useability, need for adaptation).
<p><i>Procurement</i></p> <ul style="list-style-type: none"> • Can products be purchased, fabricated, leased? 	<ul style="list-style-type: none"> • Information about purchasing options is available.
<p><i>Pace</i></p> <ul style="list-style-type: none"> • Can products be obtained in a timely fashion? • How easily and quickly can servicing and repairs be done? • For those with rapid developmental changes, how easily and quickly can upgrades be obtained? 	<ul style="list-style-type: none"> • Evidence that products are available in a timely manner. • Evidence of timely turnaround in product provision. • Evidence that services are available in a timely manner. • Evidence that consumer-standards for servicing and repairs are met. • Evidence that product updates and innovation are available in a timely manner.
<p><i>Promotion</i></p> <ul style="list-style-type: none"> • Are promotional materials attractive and credible? • Are promotional materials informative and understandable? • Are promotional materials available and easily accessible? 	<ul style="list-style-type: none"> • Evidence that products have high customer satisfaction ratings. • Specifications and manuals are easily accessible and understandable. • Operations manuals are comprehensive and understandable, and available in accessible formats.

(Scherer et al., 2019; Smith et al., 2018)

Discussion

Applications of the WHO and GAATO Frameworks

The broad global analysis of the 5Ps and GAATO Models creates a framework for understanding and addressing AT outcomes in a new way, particularly in how the AT outcomes and their impacts are collected and documented. Firstly, the way in which AT outcomes are documented and the methodologies used varies considerably across geography, types of assistive products, provision settings, the level of mandate for research, and funding sources. This vexing issue has challenged those working in the AT sector for many years. For example, at times, the outcomes and benefits of AT interventions are explicit and, thus, do not seem to require data about outcomes. Paradoxically, for people not working directly in the field as providers, e.g. funders or policymakers, measurement and documentation of AT outcomes are very important to be able to demonstrate evidence of the effectiveness of AT interventions (Clayback et al., 2015). Interestingly, the lack of evidence can also justify the limiting of funds (Smith, 2016). This is a conundrum of evidence-based funding. Funders can say they need evidence of outcomes to approve funding but, if policymakers do not require collection of data to measure outcomes when AT is provided, then this will not be documented, and funders will not have the evidence they need to support the provision of AT. From the perspective of the WHO Ps, this concept is clear and helps to understand the problem. The **People** need the Assistive **Products**. Trained **Personnel** develop and implement the **Provision** mechanisms to assess and document the needs, but, if no **Policymakers** mandate the collection of data to measure outcomes after the AT is provided, no evidence is available to advocate that **People** receive the **Products**. This is a frustrating situation where the barrier to **People** receiving needed **Products** is the lack of a system to measure outcomes.

A second example applies to the use of innovative research methodologies. While randomized clinical trials (RCTs) are the accepted standard for creating evidence to report the outcomes of interventions, innovative outcomes research methodologies are conducive to developing AT. For example, in the area of special education, the use of the single case study design (N = 1 study) has been used effectively to document AT outcomes. In epidemiological research, population-based research is primarily used, and registries have become more welcome as a method of intervention discovery (Blumenthal et al., 2018; Smith, 2016). Currently, in the field of computer science, the concepts of big data, data intensive science, the cloud, and artificial intelligence are popular because large intervention data sets can lead to better outcomes predictions. However, these new outcomes methodologies are poorly understood by most **People**, **Provision** programs, and **Personnel** in the field, and are mostly ignored by **Policymakers** and funding agencies. Therefore, these new methodologies for assessing outcomes are not often used. From the perspective of the GAATO framework (GAATO, 2022b), there is a **Need** for better **Measurement** to **Document Inputs**, and **Measure Outcomes** and **Impact** as a **Shared** system to **Inform Policy**.

Lastly, use of mobile phones is a particularly rich example of how the GAATO framework can be applied to AT outcomes. Specifically, to inform potential opportunities to develop outcomes policy across global regions, countries, and local differences. Beyond paper-based data collection methodologies, high mobile phone penetration rates in low- to middle-income countries might be an opportunity to harness the advantages of mobile technologies, not only to increase access to AT, but also to create, administer, aggregate, and report (real-time) AT outcomes. The global AT sector needs new methods to collect, document and analyse data about AT outcomes to move forward. Using the GAATO framework, accessing mobile phones can produce a method to **Measure** the **Need**, **Document** the **Inputs** of AT use and intervention, serve as a platform for **Measuring Outcomes**, and **Measure Impact** while Sharing the **Data** that are acquired electronically through

mobile phone networks. These broad data collection networks can compile and evaluate accumulated data to **Inform Policy**.

A number of challenges, gaps, and opportunities related to AT outcomes have also been identified from the literature and from expert data sources such as the WHO and GAATO Global Consultation. These include: (1) the lack of consistent terminology and concepts, which creates barriers to effective collaboration and knowledge translation; (2) existing structures which hamper innovation, e.g. responsibility for leading change, which can be addressed through high-level agreement regarding global priorities, such as the Sustainable Development Goals, the Convention on the Rights of Persons with Disabilities, and Rehabilitation 2030 (WHO, 2023); and (3) creating the infrastructure for a process to measure and document outcomes of the AT system, which is not a standard process for practitioners or researchers (refer to the Tasks listed in Table 7).

Table 7: Proposed Process to Develop a System to Measure AT Outcomes

STEPS	
Step 1	Commit to creating a system to measure AT outcomes and articulate purpose
Tasks	<ul style="list-style-type: none"> • Draft and revise purpose. • Document audience(s) for reports generated by the system.
Step 2	Identify INGO(s) (what is to be measured in what contexts?)
Tasks	<ul style="list-style-type: none"> • Specify target Population(s) of users. • Specify target Population of secondary users and other people affected, e.g. co-workers. • Specify target Products of interest. • Specify exact features of target Products of interest. • Specify target Product Performance areas of interest. • Specify target Situations and Environments.
Step 3	Identify outcome(s) of interest for each component of the AT system
Tasks	<p>PEOPLE, for example:</p> <ul style="list-style-type: none"> • Functional areas of interest fulfilled (quantitative or qualitative change); • Well-being; • Expected and realized benefit; • Goal attainment.
	<p>PRODUCT, for example:</p> <ul style="list-style-type: none"> • Durability; • Reliability; • Cost, safety and comfort; • Complexity of device usage; • Delivery and set-up time; • Need for maintenance and repairs.
	<p>POLICY, for example:</p> <ul style="list-style-type: none"> • Regulatory requirements met; • Compliance with voluntary standards; • Discretionary funding available for purchase by end-users or by third-party funders.

STEPS	
	<p>PROVISION, for example:</p> <ul style="list-style-type: none"> • Waiting list, turnaround time acceptable; • Essential trained specialists available; • Essential validated assessments available; • Partnerships forged, e.g. vocational rehabilitation; • Discretionary funding available for purchase by end-users or by third-party funders.
	<p>PERSONNEL, for example:</p> <ul style="list-style-type: none"> • Appropriate qualifications obtained; • Feasible caseload with available time; • Resources available. • Continuing education provided. • Specify P's of interest (from the framework under Step 3). • Specify Measurement Domains within each P of interest.
Step 4	Review and identify measurement instruments for outcomes
Tasks	<ul style="list-style-type: none"> • Locate existing measurement instruments that measure the outcomes within relevant P's. If no instruments are available or found, consult experts to consider: <ul style="list-style-type: none"> ○ Using non-AT specific instruments as: <ul style="list-style-type: none"> ▪ Pre/Post AT intervention or ▪ With/Without AT intervention ○ Development of a new instrument. • Select outcomes measurement instrument(s).
Step 5	Decide on data collection mechanism.
Tasks	<ul style="list-style-type: none"> • Decide who will collect the data and how they will be found. • Identify or create incentives for data collectors. • Determine what privacy and data security protocols are needed. • Select technology or technologies for data collection, e.g. mobile phones, paper and pencil etc.
Step 6	Decide on data collection frequency (minimum)
Tasks	<ul style="list-style-type: none"> • Collect baseline data (before or without use of AT products). • Record result of intervention (after or without AT intervention). • Schedule ongoing data collection (follow-up).
Step 7	Create database infrastructure
Tasks	<ul style="list-style-type: none"> • Select where the data will be stored. • Determine how the data will be compiled, cleaned, managed and maintained.
Step 8	Design reports for outcomes data
Tasks	<ul style="list-style-type: none"> • Specify audience(s) for reports. • Specify content of reports. • Decide frequency of reports. • Select media for outcomes reports and methods of distribution to audience(s).
Step 9	Create sustainability plan for outcomes assessment
Tasks	<ul style="list-style-type: none"> • Identify ongoing funding for the outcomes measurement system.

(Clayback et al., 2015; Smith. R., 2016; Fitzgerald et al., 2007; Blumenthal et al., 2018; James et al., 2022; GAATO, 2022b; and WHO, n.d.)

Outcomes and Benefit

Consideration of the issues discussed in this paper is a priority for the AT sector and is essential for the implementation of new AT programs and for updating existing services, research, and development processes. The historical and current scientific status of AT outcomes were summarized and were mapped thoroughly against the GATE 5P model for strengthening access to AT. AT outcomes must be considered holistically from both the evidence-based practice and practice-based evidence perspectives to address the complex system of assistive technology adequately. Furthermore, this paper is a call to action and a beginning point for a knowledge translation process that has the potential to unite the AT sector around the globe in cooperative action. The 5Ps and GAATO Models provide excellent conceptual frameworks for such an undertaking, which has the potential to create real change and opportunities centered around AT, disability, and related health issues.

With the launch year of the WHO/UNICEF Global Report on Assistive Technology (2022) as well as the unprecedented development of international, mission-led, AT bodies (Layton et al., 2020), the time is right to establish new methods for collection and analysis of data to measure AT outcomes for documentation and discovery (Lenker et al., 2021). To be in a position to deliver a system which builds on the rich history described above, and to reach consensus of opinions to guide future actions and collaboration, a process to develop a system to measure AT outcomes is proposed in Table 1.

This perspective paper has reviewed the development of outcomes in assistive technology research and emphases over time. Looking forward, it will be important to work globally to achieve outcomes of technology benefit in multiple arenas. It is proposed that the 5P model serves as an integrative model to enhance and guide research on AT outcomes. The imperative to act is provided within the Global Report on Assistive Technology and documents by GAATO. Multiple points of measurement—from need through inputs and outputs, and the necessity for shared vocabulary, data systems and a link back to policy—are clearly required. It is hoped that the reflections provided in this paper contribute to a future direction.

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Declarations

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Voices from Academia

Actual and Preferred Methods for Learning to Use Assistive Technology

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Abstract

This study investigated the preferred and actual methods for learning assistive technology (AT) by employed individuals who are blind or have low vision. Hands-on training was the preferred method for learning to use new AT, particularly among those who lost vision later in life. However, most participants considered self-training as their primary actual learning method. The findings indicate a need for more formal training opportunities and suggest a gap between this need and the availability of training by qualified professionals. The findings also suggest content to incorporate into formal training, including utilizing mobile apps, developing problem-solving skills, and locating and using training resources available online. AT trainers should emphasize to their students the ongoing, lifelong learning needed to maintain and enhance AT skills and knowledge.

Keywords: assistive technology, training, blind, low vision, employment

Actual and Preferred Methods for Learning to Use Assistive Technology

Assistive technology (AT) is critically important for employment and daily living for people who are blind or have low vision. Employment rates for people with blindness and low vision have historically been much lower than for people without disabilities (McDonnall & Sui, 2019). The current gap in employment rates between these groups is 28 percentage points (U.S. Census Bureau, 2022). Our world is becoming increasingly digitally dominated, if not digitally dependent. The same is true for most workplaces; a recent study found that 92% of jobs today require digital skills and that jobs requiring more digital skills earn more (Bergson-Shilcock et al., 2023). Digital skills are the ability to use digital devices, communication applications, and networks to access and manage information, and they include entry-level or basic skills (such as using email, word processing programs, and spreadsheets) and advanced or industry-specific skills (such as electronic medical records and AutoCAD; Bergson-Shilcock et al., 2023; UNESCO, 2018). For people with blindness and low vision to obtain digital skills, AT skills are essential as AT allows them to access digital tools. Just as obtaining digital skills takes time, so does learning to utilize AT effectively. We currently have limited information about how people typically learn to use AT. Therefore, the purpose of this study was to investigate preferred and actual methods for learning AT by employed people who are blind or have low vision. We also evaluated relationships between age and age of onset with preferred learning methods and self-perceived skill level with actual learning methods.

Target Audience and Relevance

The target audiences for this paper are all professionals who work with individuals who are blind or have low vision to help them obtain skills that contribute to their employment. A primary audience within that group is professionals who help people learn to utilize AT, which includes certified assistive technology instructional specialists (CATIS) and other AT instructors, teachers of students with visual impairments (TVIs), and certified vision rehabilitation therapists (CVRTs). We believe this study's findings are relevant to all blindness-field professionals because they provide novel information about how employed people who are blind or have low vision prefer to learn AT and actually did learn the AT they use at work. This information is relevant to one of their practice's purposes: to help prepare people with blindness and low vision for employment. In addition, our findings are relevant to manufacturers and vendors who want customers to learn to utilize their AT successfully.

Background

Although the extent of AT for individuals who are blind or have low vision has grown substantially in recent years, its adoption varies. Several theories have been proposed to explain the process of technology adoption, and this topic has been widely studied (Koul & Eydgahi, 2017; Salahshour Rad et al., 2018). A few studies have focused specifically on AT adoption by people with blindness and low vision. Variability in adoption can be influenced by an individual's needs and the purpose of use, whether for school, work, or independent living (Turkstra et al., 2023). Practical factors such as affordability, usability, functionality, and efficiency have been associated with the likelihood of adopting an AT (Kim, 2021, 2022; Li et al., 2021; Moon et al., 2022). Another factor that may impact AT adoption is the learning curve associated with new AT, which can often be steep (Kim, 2022; McDonnall & Steverson, 2023).

A limited amount of research has explored how individuals who are blind or have low vision learn to use AT or their preferences for learning AT. Most of the literature on how individuals who are blind or have low vision learn to use AT focuses on school-aged individuals, who often learn to use AT from TVIs, family, and peers (D'Andrea, 2012; Hewett et al., 2017; Wong & Cohen, 2011). For example, TVIs may expose students to screen magnification, screen readers, speech-to-text, or other AT that makes schoolwork accessible. However, this AT training may be inconsistently delivered, inadequate, or inefficient (Wong & Cohen, 2011; Zhou et al., 2011). In addition, the number of AT skills considered necessary for high school students to succeed in college has increased significantly (Kelly & Kapperman, 2018). When formal training for AT is not readily available, this may necessitate informal training from family members or others who may have limited knowledge of AT (Kelly & Kapperman, 2018; Wong & Cohen, 2011). Some students also engage in self-training via built-in help options or trial and error to advance their proficiency (D'Andrea, 2012).

Little is known about how adults with blindness and low vision learn to use AT, even though AT needs change across the life course. A survey conducted by the American Foundation for the Blind (AFB) examined how participants initially learned to use AT and who taught them (Silverman et al., 2022). Out of 300 participants, vocational rehabilitation (VR) staff and TVIs were most frequently reported as the initial instructors for AT, at 43% and 42%, respectively. Other commonly reported AT instructors were staff at agencies for the blind (27.7%), AT company personnel (21.7%), or another blind or low vision individual (20.7%), while 11.3% of participants reported being self-taught (Silverman et al., 2022).

A study that investigated the replacement of traditional AT (e.g., screen readers, magnifiers) with mainstream devices (e.g., smartphones) by people who are blind or have low vision found that learning methods differed between traditional AT and mainstream devices (Martiniello et al., 2022). Self-training and web-based resources were the two most frequently reported learning methods at 58% and 52% for traditional AT devices, 69% and 58% for smartphones, and 75% and 46% for tablets (Martiniello et al., 2022). Assistance from other blind and low vision users was also a common way to learn AT, reported by 42% for traditional AT devices, 43% for smartphones, and 21% for tablets. A key difference was found in the share of users who received training from vision rehabilitation professionals at 42% for traditional AT devices compared to 7.5% for smartphones and 7% for tablets (Martiniello et al., 2022).

One qualitative study of AT in the workplace found that training methods vary, although the study sample consisted of only five participants (Wahidin et al., 2018). In this study, some AT users reported seeking basic training on AT from agencies that serve the blind and low vision population but then turned to self-training to advance their skillset, while other AT users relied on self-training from the outset (Wahidin et al., 2018). Another study, using a convenience sample of 20 older adults, found that these individuals were more likely to rely on family and friends (sighted and visually impaired) to learn AT and preferred in-person AT assistance (Kim, 2021). Older learners who are blind or have low vision perceived one-on-one training as more efficient, and desirable, than user manuals or similar resources (Piper et al., 2017). Research on AT use among older people, regardless of disability status, found the lack of availability or awareness of formal training from service providers to be a primary barrier to their use (Yusif et al., 2016). While a preference for in-person or formal training may be due to generational differences in technology use or comfort with technology, it may also potentially be associated with the age at which vision loss occurred.

The availability of user resources, such as podcasts, online videos and webinars, and online discussions,

may contribute to the frequency of self-training as an option for learning AT. AT users perceived these resources as useful tools for improving their AT skills, learning about new AT, keeping their AT up-to-date, or solving compatibility issues (Silverman et al., 2022). Another factor potentially contributing to self-training of AT is that some professionals tasked with teaching AT may not be well prepared. Many TVIs have deficits in knowledge about AT competencies and a majority lack confidence in teaching AT (Zhou et al., 2011, 2019) and vision professionals rated their AT-assistance skills in the medium range (ATIA, 2022). These limitations may be linked to the extensive amount, high cost, and rapid development of AT, making it difficult for service providers to attain expert-level proficiency in multiple technologies (D'Andrea, 2012). In addition, there is a shortage of qualified AT professionals (ATIA, 2022; Kelly & Tikun, 2017; Parker, 2020). Although formal training may be lacking, there is a demand for hands-on, in-person training, particularly as a resource for increasing AT skills, as reported by approximately 25% of participants in an open-ended item in the AFB study (Silverman et al., 2022).

There is some evidence that AT learning methods may vary by age at vision loss. People who experienced vision loss after age 60 were more likely to rely on training from service providers for mainstream technologies (Martiniello et al., 2022). Older individuals with visual impairments who were already users of mainstream technology may more easily learn and adopt the accessibility features and third-party mobile applications to assist in their daily activities (Kim, 2021). Thus, proficiency with technology, rather than age or age at vision loss, may reduce learning curves for new AT.

To increase our knowledge about how employed adults with blindness and low vision learned to utilize their AT and their preferences for learning new AT, we investigated research questions 1–4 below. In addition, the fifth question represents an exploratory investigation, given that research has not been conducted regarding a relationship between AT learning method and skill level.

1. How do employed people prefer to learn to use new AT and updates to their existing AT?
2. Does preferred learning method differ based on age or age at vision loss?
3. How do people who are blind or have low vision learn to use their workplace AT?
4. What percentage of employed people with blindness and low vision received formal training to learn their AT?
5. Is primary learning method for a specific AT associated with perceived skill level for that AT?

Methods

Data Source and Participants

Study data are from the second survey of a 5-year longitudinal study focused on the use of AT in the workplace. The study was determined to be exempt by the authors' university's Institutional Review Board for the Protection of Human Subjects and represents the perspectives of the authors. For inclusion in the longitudinal study, participants had to be age 21 or older, blind or have low vision, and employed. Data collection for the second survey occurred between May 2022 and August 2022. The sample for this study includes 314 participants who answered questions about their AT used on the job, preferred methods for learning new AT and updates to existing AT, and the actual learning methods for AT devices. Participants rated their perceived skill level for particular AT devices and provided their demographic information in the first questionnaire of this study, and these data were combined with participant responses to the second questionnaire for this study. Information about the first questionnaire is available in existing publications (McDonnall et al., 2023a; McDonnall et al., 2023b).

Participants' ages ranged from 22 to 70, with a mean of 46.3 years ($SD = 11.83$). Most were female (61.5%), White (84.7%), blind or had minimal functional vision (81.2%), and had a bachelor's degree or higher (81.8%). While most participants (97.5%, $n = 306$) were from the United States, a few (2.5%, $n = 8$) were from Canada. Participants represented 42 states plus the District of Columbia and four Canadian provinces. Table 1 provides additional participant demographic information.

Table 1: Participant Demographics

Variable	<i>n</i>	%
Gender		
Female	194	61.6
Male	121	38.4
Race ^a		
American Indian or Alaska Native	5	1.6
Asian	20	6.4
Black or African American	21	6.7
Native Hawaiian or Other Pacific Islander	2	0.6
White	267	84.7
Other race	12	3.8
Hispanic Ethnicity		
Yes	25	8.0
No	289	92.0
Age Categories		
21-30	31	9.9
31-40	84	26.8
41-50	77	24.5
51-60	84	26.8
61 or older	38	12.1
Vision Loss Onset		
Preschool	214	68.2
Kindergarten-12 th grade	47	15.0
Post school	39	12.4
40 or older	14	4.5
Education Level		
High school diploma or equivalent	10	3.2
Associate, vocational, or technical degree or certificate	47	15.0
Bachelor's degree	118	37.6
Master's degree	112	35.7
Professional or doctoral degree	27	8.6
Level of Vision		
Totally blind	190	60.5
Legally blind with minimal functional vision	65	20.7
Legally blind with some functional vision	48	15.3
Low vision, not legally blind	11	3.5
Additional disability		
Yes	112	35.7
No	202	64.3
SSI		

Variable	<i>n</i>	%
Yes	15	4.8
No	299	95.2
SSDI		
Yes	72	22.9
No	242	77.1
Braille Skills		
No braille skills	50	15.9
Minimal braille skills, such as using uncontracted Grade One braille	39	12.4
Moderate braille skills, such as some use of contracted Grade Two braille	43	13.7
Proficient braille skills, fluent in contracted Grade Two braille	182	58.0
Employment Type		
Employer job	217	81.9
Self-employed	29	10.9
Both	18	6.8

^a Participants selected all races that applied.

Participants selected the AT devices they used on the job from a list of 29 AT devices. For this study, we included 10 of the most commonly used AT at work. Three of these devices were commonly used by participants who were legally blind with some functional vision or low vision (third-party screen magnifiers, built-in screen magnifiers, and electronic video magnifiers) and seven were commonly used by participants who were blind or legally blind with minimal functional vision (third-party screen readers, built-in screen readers, optical character recognition (OCR) apps, refreshable braille displays, OCR software and hardware, orientation and navigation apps, and braille notetaking devices).

Measures

Preferred Learning Methods

Participants were provided a list of eight preferred methods for learning to use new AT devices or software and asked to select their first, second, and third choices. The eight options were (a) having someone teach me (hands-on training), (b) reading online tutorials and/or user resources, (c) email or online listservs/user groups, (d) listening to recorded tutorials, (e) participating in a live webinar where I can ask questions, (f) reading the manual and trying it out on my own, (g) figuring it out by trial and error, and (h) using the built-in help features.

Participants identified their first, second, and third options for preferred learning methods for updates to their existing AT devices or software. Participants had the same eight choices from the preferred learning methods with two additional choices: (a) reviewing update details through written, audio, or video releases from the vendor and (b) talking to my friends or colleagues about the updated features. For both preferred learning method variables, the authors collapsed the first-choice responses into three-category variables for chi-square analyses: (a) self, (b) resources, and (c) training. These 3-category variables for preferred learning methods for new AT and preferred learning methods for updates were further collapsed into two-category variables for the trend analyses: (a) training and (b) other.

Actual Learning Methods

Participants identified all the actual ways they learned to use each selected AT from a provided list. If they selected more than one method, they then identified which method they considered their primary learning

method. The question to determine their primary AT was worded: “Of the methods you selected, which do you consider the primary way you learned to use _____ (the specific AT)?” The options provided to the participants were (a) in school (taught by TVI), (b) training provided through VR agency or agency for the blind, (c) vendor, (d) self-taught, (e) tutorials, (f) another person with blindness or low vision, and (g) other. An eighth category, “other training,” was created from “other” write-in responses that mentioned training that did not fit an existing category.

We created a training variable to indicate type of training received. If a participant selected taught by a TVI, VR or agency training, vendor, or other training, this was classified as *received formal training*. If the participant indicated that another person with blindness or low vision taught them, this was classified as *received informal training*. If the participant did not report any of these, they were considered to not have received training.

Age and Age at Onset

Participants’ ages were calculated based on their month and year of birth subtracted from the month and year of data collection. The authors then created an age category variable with five levels (i.e., 21–30, 31–40, 41–50, 51–60, and 61 or older). Participants reported their age when they first experienced serious difficulty seeing. From that information, the authors generated a 4-category age of onset of vision loss variable: preschool (ages 0–4), K–12 (ages 5–18), post-school (ages 19–39), and age 40 or older.

Self-Perceived Skill Level

Participants rated their perceived skill level with each specific AT they used at work on a 10-point scale (1 = *beginner*, 10 = *advanced*) in the first survey. This variable was used for the analyses to answer research question 5. The first questionnaire did not separate built-in screen readers and magnifiers but instead included a combined AT (built-in accessibility features on a computer). Therefore, we were unable to assess skill level by learning method for those two ATs.

Data Analysis

We used SAS 9.4 to conduct all analyses. Descriptive statistics (i.e., means, standard deviations, and frequencies) were used to determine participant demographics, learning preferences for new AT and updates to existing AT, actual methods to learn to use AT, and percentage who received formal training (research questions 1, 3, and 4). We used chi-square analyses and the Cochran-Armitage trend test to investigate the relationship between preferred learning methods and participants’ age and age at vision loss (research question 2). Analysis of variance (ANOVA) was used to investigate the relationship between participants’ primary learning method for specific AT and perceived skill level (research question 5). Actual learning methods with less than 4 observations (skill ratings) in a category were not included in these analyses.

Results

To address research question 1, Figure 1 displays the methods participants preferred for learning to use new AT devices and software, including their first preferred method. Figure 2 displays participants’ preferred methods for learning about new features or updates to AT they already use.

Figure 1: Preferred Methods for Learning to Use New AT Devices or Software

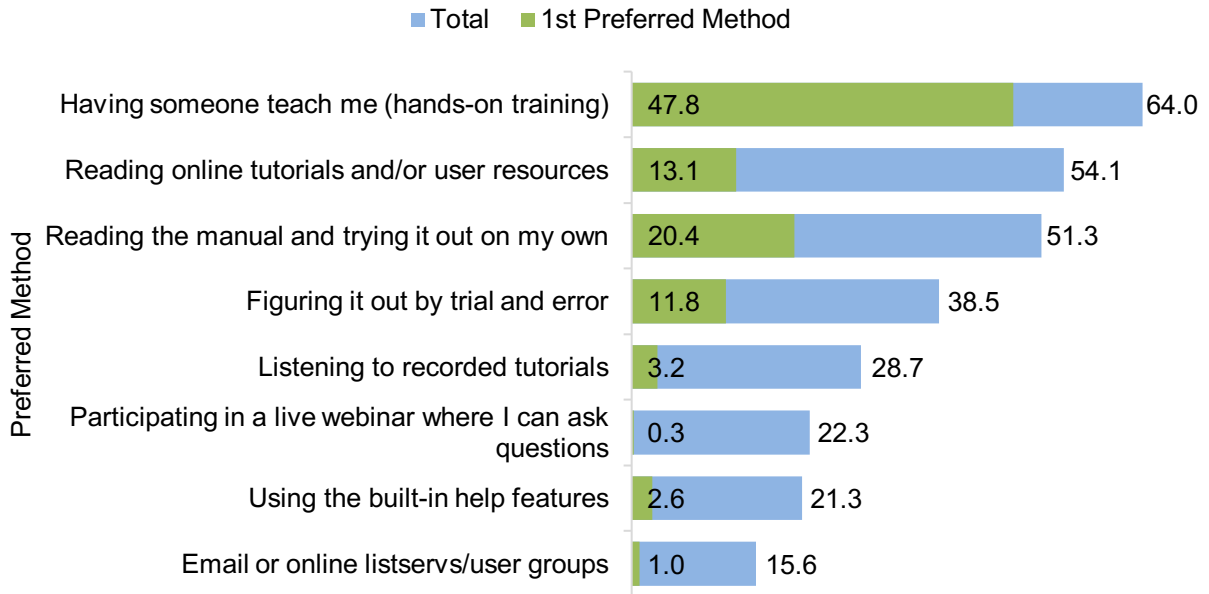
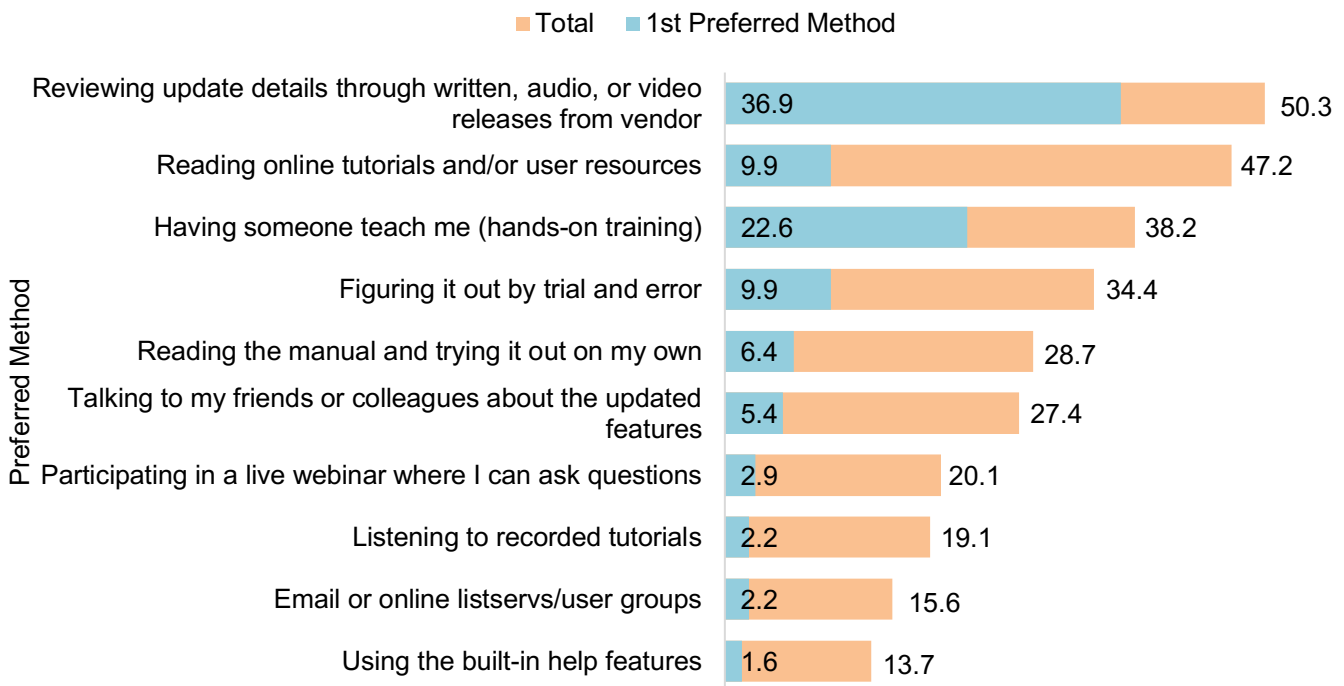


Figure 2: Preferred Methods for Learning to Use New Features or Updates



Participants' preferred learning methods for new AT devices ($X^2(8, N = 314) = 1.70, p = .99$) or updates to existing AT ($X^2(8, N = 314) = 5.08, p = .75$) did not differ based on age. However, there were significant differences based on participants' age at vision loss (see Table 2 for chi-square results). There appeared to be a trend for a preference for training as age of onset of vision loss increased, which was tested with the Cochran-Armitage trend test (Z statistic). As the age of vision loss onset increased, participant preference for

training (compared to any other method) increased for new AT devices ($X^2(3, N = 314) = 16.28, p = .001; Z = -3.90, p < .0001$) and for updates to existing AT ($X^2(3, N = 314) = 23.30, p < .0001; Z = -4.66, p < .0001$).

Table 2: Actual Learning Methods for AT Used at Work

Variables	<i>n</i> Pre-school	% Pre-school	<i>n</i> K-12	% K-12	<i>n</i> Post-school	% Post-school	<i>n</i> 40+	% 40+	X^2	<i>p</i>	Φ
New AT Learning Method									16.82	.01	.23
Resources	41	19.2	7	14.9	6	15.4	1	7.1			
Self	87	40.7	12	25.5	7	18.0	3	21.4			
Training	86	40.2	28	59.6	26	66.7	10	71.4			
AT Updates Learning Method									26.01	<.01	.29
Resources	51	23.8	12	25.5	8	20.5	0	0.0			
Self	130	60.8	19	40.4	17	43.6	6	42.9			
Training	33	15.4	16	34.0	14	35.9	8	57.1			

Table 3 presents the actual methods participants used to learn their workplace AT, including their primary learning method. Table 4 presents the percentage of participants who received formal, informal, or no training on the ten specific AT.

Table 3: Actual Learning Methods for AT Used at Work

AT Device/Software/App	Self-taught	VR/Agency training	Tutorials	Person with VI	In school (by a TVI)	Vendor	Other	Other training
Screen reader software (3 rd party)	81.9 (44.2)	57.0 (25.3)	66.0 (12.8)	55.9 (8.3)	23.8 (7.9)	21.5 (0.8)	4.2 (-)	3.8 (0.8)
Screen magnification software (3 rd party)	88.5 (67.3)	46.2 (26.9)	30.8 (1.9)	15.4 (-)	9.6 (1.9)	9.6 (1.9)	1.9 (-)	1.9 (-)
Built-in screen reader	88.1 (66.1)	31.4 (11.0)	66.1 (6.8)	40.7 (11.0)	15.3 (1.7)	17.0 (1.7)	3.4 (-)	2.5 (1.7)
Built-in screen magnification	92.5 (87.5)	22.5 (5.0)	30.0 (-)	15.0 (2.5)	5.0 (2.5)	7.5 (2.5)	-	-
OCR software or hardware	81.2 (60.2)	30.8 (14.3)	38.4 (7.5)	30.1 (9.0)	7.5 (4.5)	18.1 (3.8)	2.3 (0.8)	1.5 (-)
Braille notetaking device	88.6 (62.0)	20.3 (5.1)	57.0 (10.1)	30.4 (7.6)	21.5 (10.1)	32.9 (3.8)	-	2.5 (1.3)
Refreshable braille display	90.8 (70.0)	16.2 (6.2)	56.9 (12.3)	29.2 (5.4)	9.2 (2.3)	20.0 (3.1)	0.8 (-)	0.8 (0.8)
Electronic video magnifier	71.8 (56.4)	41.0 (23.1)	25.6 (-)	12.8 (2.6)	10.3 (10.3)	15.4 (7.7)	-	-
OCR app	89.9 (76.7)	10.7 (4.1)	30.0 (9.6)	26.4 (8.6)	0.5 (-)	4.1 (-)	2.0 (1.0)	-
Navigation/wayfinding app	87.7 (71.9)	14.0 (6.1)	30.7 (7.0)	31.6 (12.3)	2.6 (0.9)	5.3 (1.8)	1.8 (-)	-

Note. All numbers are percentages. The numbers in parentheses represent the percentage who reported that method as their primary learning method. VI = visual impairment. TVI = teacher of students with visual impairments.

Table 4: Percentage who Received Formal, Informal, or No Training for AT Used at Work

Assistive Technology	Received formal training	Received informal training	Did not receive training
Third-party screen reader software	72.0	9.6	18.5
Electronic video magnifier	62.5	7.5	30.0
Third-party screen magnification software	59.6	5.8	34.6
Braille notetaking device	56.3	8.8	35.0
OCR software or hardware	45.9	14.8	39.3
Built-in screen reader	45.1	14.8	40.2
Refreshable braille display	35.1	16.8	48.1
Built-in screen magnifier	29.3	4.9	65.9
Navigation/wayfinding app	19.8	20.7	59.5
OCR app	13.0	23.5	63.5

Note. Received formal training includes training by a teacher of students with visual impairments, VR or other agency for the blind or vendor, or other. Received informal training includes people who learned by another person who is visually impaired and did not receive formal training.

Table 5 presents the perceived skill level means by primary learning methods for the specific AT. The primary learning methods for three AT devices were significantly associated with participants' perceived skill level: third-party screen reader software ($F(4, 248) = 2.84, p = .03$), OCR software or hardware ($F(5, 98) = 2.72, p = .03$), and OCR app ($F(3, 161) = 2.92, p = .04$).

Table 5: Means, Standard Deviations, and ANOVA for Skill Level by Primary AT Learning Method

Table Key: A = Another person with VI; I = In school (by a TVI); S = Self-taught; V = VR/Agency for the blind training; T = Tutorials

Assistive Technology	n (A)	M (SD) (A)	n (I)	M (SD) (I)	n (S)	M (SD) (S)	n (V)	M (SD) (V)	n (T)	M (SD) (T)	F	df	p
Screen reader software (3 rd party)	20	8.05 (1.39)	21	8.52 (1.21)	111	8.47 (1.36)	67	7.79 (1.46)	34	8.18 (1.40)	2.84	4, 248	.03
Screen Magnification software (3 rd party)					33	7.30 (2.34)	13	6.85 (2.27)			0.36	1, 44	.55
OCR software or hardware	8	6.28 (2.39)	4	8.50 (1.91)	66	7.50 (1.68)	13	6.31 (2.10)	8	8.25 (1.28)	2.72	5, 98	.03
Braille notetaking device	5	7.40 (3.13)	8	9.00 (1.41)	43	7.79 (2.10)	4	6.75 (2.99)	7	8.86 (1.07)	1.31	4, 62	.28
Refreshable braille display	5	8.60 (1.34)			77	7.55 (2.22)			15	7.40 (2.03)	0.62	2, 94	.54
Electronic video magnifier			4	9.75 (0.50)	22	8.00 (2.20)	7	8.14 (2.61)			0.99	2, 29	.38
OCR app	14	6.57 (1.91)			126	7.98 (2.02)	7	6.57 (3.26)	18	7.28 (2.59)	2.92	3, 161	.04
Navigation/way finding app	9	8.00 (1.22)			56	7.70 (1.72)	5	7.80 (2.28)	5	8.40 (1.14)	0.33	3, 71	.81

Note: OCR software or hardware: Vendor n = 5, M = 8.60, SD = 1.14. VI = visual impairment. TVI = teacher of students with visual impairments.

Discussion

Hands-on training was clearly the preferred way to learn to use new AT, with almost half of participants selecting it as their first choice and 16% more identifying it as a second or third option. Utilizing materials provided by vendors was the top preferred method for learning to use new features in updates to AT the person already used, but hands-on training was the second most preferred option. Although the preference for training as the first choice for learning both new AT and new features or updates was not associated with age, it was associated with age at onset of blindness or low vision. The older the person was when they experienced vision loss, the more likely the person was to prefer hands-on training compared to any other method. This is not surprising, given that people who have used AT for longer periods of time have likely adopted many new ATs and gone through multiple AT updates. These experiences likely made them more comfortable with managing this process on their own. However, it is important to note that a moderate to large percentage of people who experienced vision loss before or during their K–12 schooling also preferred hands-on training.

The percentage of people who received formal training for the AT they use at work varied by the AT—more than 70% of screen reader users did, but less than half of participants received formal training on most AT reviewed in this study. Rates of formal training were particularly low for the two types of apps, with one-fifth or less receiving formal training. Some participants received informal training on their AT from another person who is blind or has low vision, and this was most common for the apps. However, most participants did not receive any training, formal or informal, on the use of apps they are utilizing at work. This coincides with Martiniello et al.'s (2022) finding that few people received training on using smartphones. Satisfaction with OCR apps was lower than most other AT used at work by our participants (McDonnall et al., 2023b); perhaps this is associated with the fact that few people received training in their use. Even if OCR apps are fairly simple to operate, receiving some instruction may increase user skill and satisfaction with an AT that is used at work by the majority of people with blindness and low vision.

Despite hands-on training being the preferred learning method for new AT, self-taught was what most people considered their primary way to learn to use specific AT. Many participants reported using tutorials and other resources provided by manufacturers to help them learn how to utilize their AT, as found by Silverman et al. (2022). A considerable number of resources for learning AT are available, including written, audio, and video tutorials from manufacturers and others; webinars hosted by manufacturers and other organizations; and electronic email lists created for people to obtain assistance with AT questions. Most of this information is freely available on the internet, although newer AT users may be unaware of the resources or unsure of how to locate them.

It is likely that people who are able to teach themselves new AT possess problem-solving skills, which also allow them to better adapt to product updates. With the speed at which technology changes today, the ability to self-teach is important if not essential. It is crucial that AT professionals teach their students to find solutions to their AT problems and provide guidance in utilizing the many resources available today to self-teach (Kamei-Hannan et al., 2023). Beyond the basics of utilizing an AT, teaching students how to problem solve and find solutions for themselves to not only the issues that will arise with AT use, but also the updates to the AT, should be a top priority.

Significant differences in self-perceived skill levels were found for three ATs based on primary learning method: screen reader software, OCR software/hardware, and OCR apps. In all cases, individuals who reported learning to use AT primarily through training from VR or other agencies that serve people with blindness and low vision had lower self-perceived skill levels. Average skill levels for people who considered learning from another person with blindness or low vision (informal training) as their primary method were also generally lower than the other methods. These findings suggest that people need to consider their training as the first step in learning an AT and strive to continue to learn and increase their skill in its use. It does not necessarily indicate that the training provided was of poor quality, but it may suggest that the training dosage is not adequate. With the limited number of blind/low vision-specific AT specialists and even fewer CATIS-certified AT professionals (ATIA, 2022), individuals may not be receiving as much training as they need or desire.

Limitations

This study is based on self-reported data provided via a survey and is thus subject to the limitations that are inherent in survey research (e.g., sampling bias, measurement error, response bias). It was not possible to obtain a random sample of employed people who are blind or have low vision; therefore, our survey relies on volunteer participants who may not be representative of the entire population. Our participants may be people who have an interest in AT and are more skilled with AT than the average employed person who is blind or has low vision. Survey questions may have been interpreted differently by different respondents or may have been misunderstood. For example, participants decided for themselves how to define their primary method of learning to utilize their AT, and respondents may have defined this differently. Participants may also have intentionally or unintentionally provided misleading information. For example, participants rated themselves on their skill level with each AT, and their perceptions may not match an objective evaluation of their skill. Finally, we did not collect all information that may be relevant to this topic, such as the type of professional from whom participants received their formal training. It would be helpful for future studies regarding AT training to include this information.

Outcomes and Benefits

This study identified the preferred and actual methods to learn new AT for workers with blindness and low vision, how these preferences differ by age at vision loss, and how perceived skill level differs by actual learning methods for three of the most common workplace AT. Our findings contribute empirical evidence to the scarce literature about how people who are blind or have low vision learn to use their AT and highlight the discrepancy between preferred and actual learning methods. While hands-on training is preferred for learning new AT devices and software, actual learning is primarily through self-teaching. A large percentage of employed people did not receive formal training for some of the ATs they use at work, suggesting a gap between the desire for training and its availability.

The outcomes of this study inform training providers (CATIS, AT instructors, TVIs, CVRTs, VR and other agencies, and vendors) of the demand for hands-on training, common for all but particularly preferred among adults who lost their vision after completing their K–12 education. The relatively low proportion of participants who received training on some AT they use at work suggests that training is not as readily available as it should be. The findings of this study also suggest important content to include in formal training. Making training available on the use of mobile apps and the other devices in this study commonly used at work but

for which few received training is also important. Given the limited amount of time AT trainers may have with students, methods for troubleshooting compatibility and accessibility issues, seeking support services, as well as locating and utilizing available resources, should be key parts of the training process. These skills should be emphasized in preparation programs for AT professionals, such as those pursuing CATIS certification eligibility. Informing the student that continued learning, beyond the training sessions, is not optional but necessary may also provide the right frame of mind to encourage continuous growth. This may include learning updates to existing AT as well as new AT, employment-specific AT training needs, or daily living AT training needs. Our findings suggest that this continuous learning mindset is beneficial for obtaining the AT skills needed for successful employment.

Because almost all participants reported that they learned to use one or more of their ATs through self-teaching, tutorials, or both, our findings emphasize the value of the numerous resources available today to assist people in learning to utilize their AT effectively. Vendor-provided new release information was the most preferred way to learn updates to existing AT. For technology companies and other developers, including individuals who provide podcasts or videos, our findings indicate that continuing to develop and offer these resources is imperative.

Conclusions

In conclusion, this study documents the importance of having AT training available to people with blindness and low vision, including those who are employed. Most of our participants preferred hands-on training to learn a new AT, and many preferred training for learning updates to existing AT. This is a challenge given the limited number of qualified AT specialists specifically trained to instruct people who are blind or have low vision, especially to support training needs in employment settings (ATIA, 2022; Kelly & Tikun, 2017; Parker, 2020). Although the CATIS certification was launched in 2016 to address a long-existing demand for well-qualified AT instructors of people with blindness and low vision (Kelly & Tikun, 2017), there are currently only 135 active CATIS (<http://www.acvrep.org/verify>). There is a tremendous need to increase the number of CATIS and other qualified professionals in the blindness field to support the demand for AT training. Our findings also indicate that training should not be the end of learning to use an AT but only the beginning. Our results make it clear that ongoing learning is needed. Thus, AT professionals should prepare students to both problem-solve issues they are bound to encounter in AT use and continue to gain knowledge and advance their skills with the many resources that are available today.

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Declarations

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Voices from Academia

Integrating Assistive Technology into the Writing Process: An Example for Future Implications

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Abstract

The implementation of assistive technology tools is critical for the overall growth of individuals with disabilities. This study offers an example of ways to further integrate assistive technology in the writing process through the combination of effective writing interventions aligned with proven assistive technology tools. Through the use of the Writing Classroom and the WRITE progress monitoring tool, efforts to alter teacher technology use and subsequent student implementation is examined. Outcomes indicate that through the combination of effective writing interventions and proven assistive technology tools, teacher and student technology use will increase and subsequent student writing outcomes will improve. Implications of this study indicate that with the growth of the availability of assistive technology tools, meaningful integration can be furthered through a combination with effective instructional practices.

Keywords: writing, technology, progress monitoring, technology integration

Integrating Technology Tools to Support Writing Outcomes for Students with Disabilities

The Writing Classroom (see writingclassroom.org) is a federally funded initiative with the goal of supporting the implementation of promising assistive technology tools (e.g., interactive graphic organizers, text-to-speech, word prediction), with the support of effective writing strategies to improve writing outcomes for middle school students with disabilities (e.g., learning disabilities). Integral to this effort is the WRITE progress monitoring tool (WRITE) which is a web-based automatic scoring tool developed and housed in the Writing Classroom. WRITE offers three-minute short-writes that are then auto-scored using Curriculum-Based Measures (CBM) scoring methods. Student CBM scores are compared to national norms and recommendations are made to help increase student writing scores. WRITE provides a library of writing prompts across three genres (narrative, persuasive, and argumentative), and scores student writing based on spelling accuracy, word count, and sequencing. Teachers and students have immediate access to data graphs to compare the individual to themselves (over time), to national norms, and to their entire class.

The Writing Classroom also contains a series of instructional modules that provide just-in-time videos (average 7 minutes) and step-by-step guide sheets to direct the use of effective writing strategies paired with promising assistive technology (AT) tools. The videos and guide sheets are organized around common writing challenges (e.g., organization) and the accompanying AT tools (e.g., integrative graphic organizers). The purpose of the Writing Classroom and the WRITE progress monitoring tool is to promote the implementation of AT tools, with effective writing strategies, in order to increase the writing outcomes (quantity and quality) for students with disabilities (SWDs).

Target Audience

The target audience for the work described here includes: (1) general education teachers focused on meeting the writing needs of all learners in their inclusive classroom, (2) special education teachers supporting students with disabilities to improve writing outcomes to further support inclusion in their grade level classroom, (3) general and special education teachers seeking to further integrate growing technologies that support writing independence and in turn improve writing outcomes for struggling learners and their peers with identified disabilities, and (4) assistive technology team members that are continuously looking for ways to further implement assistive technology tools into the instructional life of SWDs. Each of these groups of educators are increasingly using technology tools to improve their instruction, enhance and support student learning, and further develop a level of independence on the part of the SWD.

Significance of Writing in the Inclusive Classroom: Impact of Students with Disabilities

A large part of school success hinges on how well a student can express what they know (Graham et al., 2019a). Central to demonstrating learning is often the task of writing (Graham et al., 2019b). Expressing one's thoughts, understanding of a concept, or what one has learned is complex. The task of writing is further complicated by its multiple components including idea generation, organization, vocabulary (e.g., discipline-specific), sentence structure or fluency, tone or voice, and the list continues (Graham & Harris, 2019). By 4th

grade, if not sooner, there is an expectation that student writing serves as the primary form of student expression often illustrated through reports, constructed responses, research papers, and essays (Childs, 2020). Even so, most 4th graders (70%: NCES, 2012) do not meet expected writing proficiency benchmarks. By 8th grade, 73% of students fail to meet these expected writing benchmarks (NAEP, 2002). For individuals with disabilities (e.g., learning disability, intellectual disability) only 6% of 4th graders and 5% of 8th graders meet writing proficiency benchmarks (NAEP, 2002). While the results from the NAEP have not been released since 2012, research supports that students with learning disabilities (SLD) continue to struggle with writing (Harris & McKeown, 2022). Graham and colleagues (2017) highlight the significant challenges in writing that students with disabilities (SWDs) experience including deficits in quality, organization, voice, ideation, sentence fluency, and overall knowledge about writing (e.g., genre, vocabulary). These writing struggles are often compounded by challenges with fine motor skills, working memory, and attention (Graham & Harris, 2019).

To meet the unique writing needs of students with disabilities (SWDs), researchers have found that these learners require: (1) to be explicitly taught the process of writing (Harris & McKeown, 2022), (2) to be provided a designated, and if possible, extended time for writing (Troia, 2014), (3) an established writing routine (Slavin et al., 2019), and (4) regular, consistent, and proactive feedback on their writing (Troia, 2014).

Essential to positive SWD writing outcomes is the use of strategy instruction (Schumaker, 2022). Instructional strategies specific to writing offer SWDs a process approach to writing from which students can further understand and then follow. Troia in his 2014 Innovation Configuration for the CEEDAR Center identifies four critical components of strategic instruction: (1) explicitly explaining the rationale and purpose for the strategy, (2) modeling how the strategy is used, (3) providing opportunities to practice and apply the strategy, and (4) adapting the strategy for the assignment and student needs (Graham & Harris, 2019). Graham and colleagues (2019) reinforce these core components by emphasizing effective strategy instruction, including (1) the establishment of a specific routine, (2) following a process approach, (3) ensuring regular opportunities to write (with supports), and (4) identifying student-oriented goals for their writing and aligning these goals with specific measurable outcomes. Troia, Graham, and their fellow researchers have found and continue to reinforce that it is not enough to simply provide for more opportunities for students to write; instead, SWDs require direct instruction in how to write combined with proven strategies that foster student understanding and further facilitate the students' skills as writers (Graham et al., 2019a; Troia, 2014).

The Role of Technology in Writing Outcomes for Students with Disabilities

Further complicating the writing process is the realization that writing in today's K–12 classroom is being conducted via a digital device (e.g., iPad, laptop, Chromebook). In the post-pandemic classroom, an overwhelming number of learners, specifically those with disabilities, have access to and are using technology as an essential part of their instructional day (Klein, 2021). For many if not all students, writing is becoming synonymous with technology (Rowland et al., 2020). These devices and/or the embedded software/browsers/applications that come with laptops, Chromebooks, or similar digital machines, are increasingly including features, supports, and tools that have historically been referred to under the umbrella of AT. For example, via the Chrome browser, Read&Write (see [texthelp.com](https://www.texthelp.com)) is an extension that can be turned on to offer word prediction, text-to-speech, student dictation, spellcheck, and a host of additional supports that can be used to increase, maintain, or improve the writing performance of a student with disabilities (Graham et al., 2019a). Thus, where previous AT often required efforts to ensure device and application availability (e.g., complete AT assessment process), the 21st century classroom is increasingly

removing that barrier through districtwide investments in supportive technologies available as part of the device and/or accompanying apps/software for all.

As Ok and Rao (2019) illustrate, the nature of these assistive tools and the growth in free and low-cost apps and extensions (e.g., Chrome) are increasingly benefiting all learners in the inclusive classroom including those with and without disabilities. Whether these tools are considered instructional or assistive technology increasingly appears to be not as critical to application as long as the student with an identified disability has access to, is provided training in, and can use the tool as designed in their overall learning (Graham & Harris, 2019). While AT tools are critical to consider and identify, the enhanced investments per student (Klein, 2021) and the tools available on these laptops, Chromebooks, and related digital platforms are now available components for instructional supports and integral to the lives of those with disabilities (Goldman et al., 2023).

Access to technology tools and embedded features that have historically been considered AT does not end the narrative. AT is meant to enable SWDs to participate in a free appropriate public education in their least restrictive environment and in the process, maintain or improve their functioning and independence. AT tools should provide a means to understand, engage, and complete academic tasks with a greater level of independence and efficacy. Thus, increased availability of technology tools and features within one-to-one devices does not negate the need to further determine the most appropriate AT tool specific to the needs of the SWD. This is particularly true when considering effective technology solutions to facilitate the writing process.

Efficacy of Technology on SWD Writing Outcomes

Peterson-Karlan's 2011 seminal article in *Assistive Technology Benefits and Outcomes* offered a descriptive analysis of over two decades of research on writing and AT tool integration for SWDs. Findings suggested a foundation of research that reinforced the promise of AT in its support of SWD writing outcomes and also identified significant gaps at all levels of the writing process, and where AT should play a role but was not. One overarching conclusion was the need for more and better research on AT and its ability to support writing for SWD. Over the past decade, researchers have explored how technology (instructional and assistive) impacts the broad writing process for SWDs. Vasquez and Straub (2016), for example, examined online writing instruction for SWDs suggesting further integration of strategy instruction with the growing tools embedded within the online learning environment. Boon and colleagues (2018) reviewed the efficacy of digital graphic organizers to improve SWD writing outcomes, identifying potential impact on improving the planning stage of the writing process. Chelkowski and colleagues' (2019) synthesis on mobile technologies and writing for SWD found an increase in basic writing skills. Likewise, Wen and Walters (2022) conducted a meta-analysis of technology's role in writing instruction for elementary SWDs. Exploring the overall impact of technology (e.g., word processing, online tools, AT) on writing performance, their analysis identified promise in improving the quality and quantity of SWDs outcomes.

Purpose

The purpose of this yearlong study was to better understand how educators in inclusive classrooms could further combine effective writing strategies that were particularly relevant to the needs of SWDs with proven AT tools. The study sought to further understand the impact that AT tools, when combined with effective writing strategy instruction, has on SWD writing outcomes. The study sought to measure the impact of the Writing Classroom (web-based support to infuse promising AT tools with effective writing strategy instruction and the accompanying WRITE progress monitoring tool) on SWD technology use and in the end, ability to

improve their writing outcomes. This study featured two specific research question(s): (1) In what measurable ways does the Writing Classroom improve student writing? (2) How does the Writing Classroom affect teacher and student use of technology supports for writing?

Methods

Knowing that technology integration and effective writing strategies need to be implemented simultaneously for students with and without disabilities to write in the 21st century classroom, the University of Kansas created WRITE and the writingclassroom.org. WRITE is a progress monitoring tool where educators have their middle school students complete digital, three-minute short-writes that are then auto-scored using Curriculum-Based Measures (CBM) scoring methods. Student CBM scores are compared to national norms and recommendations are made to help increase student writing scores. Educators are encouraged to visit writingclassroom.org to view video examples and how-to professional learning on the pairing of ubiquitous technology tools with effective writing strategies to support their students who struggle with writing. For example, educators can learn how a sixth-grade teacher from a midwestern middle school integrated interactive graphic organizers with the Self-Regulated Strategy Development strategy, STOP, to brainstorm a persuasive essay. They can watch a how-to video, see the educator model the practice, print how-to step-by-step guides, and find links to additional resources on the web.

Participation & Setting

We recruited a total of 28 middle schools from three different states (Kansas, Iowa, and Tennessee) across over 20 school districts. Most of the schools (>75%) included populations where over half of the students were eligible for free or reduced lunch. In sum, 21 schools from Kansas, five schools from Iowa, and two schools from Tennessee participated. A total of 44 general and special education teachers participated, and the reach of the intervention spanned 1,569 students in 6th, 7th, and 8th grades. Of those 1,569 students, approximately 100 students were identified by their teachers as having learning disabilities. Teachers identified additional students served under 504 Plans and an additional group identified as struggling learners (e.g., struggling readers) not being served under an identified service but part of tiered-based interventions. All teachers were assigned to teach at least one English Language Arts class as part of their instructional day. All general education middle school teachers were English Language Arts teachers. Special education teachers co-taught in the inclusive classroom or in an independent resource room which focused primarily on writing instruction.

Procedures

Educators across all middle school classrooms were required to integrate the self-regulated strategy development (SRSD) instructional approach. While teachers could select variations of the SRSD (e.g., POW-Pick, Organize, Write), they were required to integrate the scaffolded instructional sequence of the SRSD approach including: (1) Discuss It, (2) Model It, (3) Make it Your Own, (4) Support It, and (5) Independent Performance. Likewise, teachers were also required to select at least one proven AT tool (interactive graphic organizer, text-to-speech, word prediction) and combine this AT tool with the SRSD approach.

To assist teachers with an understanding of the SRSD approach, the proven AT tools, and to facilitate the combination of the two within the middle school classroom, teachers were provided access to instructional learning modules, step-by-step directions, and virtual instructional coaching. The learning modules and

supportive step-by-step directions were provided via writingclassroom.org. Iteratively developed to facilitate strategy instruction combined with AT tools to support SWDs writing outcomes, the Writing Classroom was structured around strategy instruction and three primary AT tools to assist writing instruction. The SRSD writing approach was introduced via eight potential areas of writing challenges for SWDs (e.g., conventions, organization, spelling). Likewise, the AT tools were structured around three primary areas: (1) interactive graphic organizers, (2) text-to-speech, and (3) word prediction. Each of the writing and technology areas featured videos and step-by-step user guides to explicitly illustrate (to the teacher) ways to apply the SRSD instructional approach with a proven technology tool. All participating teachers were provided full access to the entire Writing Classroom site. Instructional videos averaged about 7 minutes in length. Each instructional video was accompanied by a step-by-step user guide. Instructional coaches used these instructional materials to support teacher understanding and to further facilitate strategy and AT use and subsequent classroom implementation.

Two virtual (via the video-conferencing application [Zoom.com](https://zoom.us)) instructional coaches provided weekly support to all participating teachers. Each participant began the study by measuring student writing needs through the use of the WRITE Progress Monitoring tool (WRITE). As described under the Measurement section of this article, WRITE measured students on basic writing skills of word count, spelling, and sequencing. Teachers conducted a bi-weekly student measurement of student writing performance via WRITE. After the initial progress monitoring assessment was completed, teachers individually met with their assigned virtual coach (VC) to review findings. After the first meeting, classroom teachers, with the assistance of their VC, determined a process whereby they would continue to collect data (WRITE administered at least once every two weeks), and from these student data, identify instructional goals that would lead to the identification of at least one SRSD instructional approach and one AT tool (interactive graphic organizer, text-to-speech, word prediction). Subsequent coaching sessions would determine ways to implement the strategies and tools and ways to understand student data; they would determine subsequent student needs, identify further adjustments to implementation efforts, and identify ways to assess their classroom goals to determine modifications and/or success.

Weekly virtual instructional coaching sessions were held with each participant for the first month of the study. Subsequent meetings were determined by the coach and classroom teacher. Each coaching session was documented through coaching logs by the VC collecting information on what was discussed with the teacher, which of the strategies were investigated by the teacher, and which of the Writing Classroom materials were being used by the teacher. This was followed by an exploration of the student data walks conducted by the teacher. The purpose of these sessions was to ensure an understanding of what specifically occurred during each virtual instructional coaching session. Coaching logs were available via a Google Doc and identified the date, time, and narrative of what occurred and what was unique to each session. Likewise, teachers were required to complete a teacher log (also via a Google Doc) where they documented the SRSD instructional approach they used, the technology tool that was used, and the process followed to implement, support students' use, and record related observations based on their application activities. To facilitate coach/teacher student data conversations, a protocol was developed. The protocol structured the WRITE progress monitoring data, utilized the graphic displays that documented each student's outcomes, and further unpacked student data for teacher understanding, decision making, and subsequent determinations on strategy and technology tool implementation.

Measures

Multiple measures were used to assess the results of this instructional strategy/technology-based intervention. With students, researchers utilized a short write-progress monitoring measure and a long write measure to determine writing progress. With teachers, researchers utilized a classroom observation measure to examine fidelity of implementation technology use of both teachers and students.

Short Write-PM Procedure and Measure

To capture a short writing measure, students used the WRITE progress monitoring system. Students were asked to open their device and navigate to the WRITE student portal. Students then entered the name of the assessment that their teacher created for them. Typically, it was a combination of the teacher's last name or school and the classroom hour that the student was in (e.g., Grissomhour1). The student also entered a password as assigned by the teacher to the whole class (e.g., "WRITE"). They would then enter their name and it would automatically pop up since the teacher had assigned them to the given assessment. The student could click on their name and then click "submit."

Students were then given a window with text, which they could have read to them, that explained how when they clicked on the "next" button, they would be given a writing prompt (one of the three genres) and a one-minute timer. They would have one minute to think about what they wanted to write, and as soon as the minute was up, they would receive a blank text box and a three-minute timer where they could begin typing. During the one minute of think time, they were encouraged to make notes about what they wanted to write about during their three-minute short write. They would then have three minutes to write, and when the three minutes was up, the window automatically closed, saving their writing for them, and the student could close their browser window. Student writing skills were assessed for 1,569 students with teachers in the WRITE group in the fall and again in the spring (pre-post intervention). They were measured on basic writing skills of word count, spelling, and sequencing using short writing samples. Paired-samples t-tests were performed to look for significant improvement across time.

Long Writing Procedure and Measure

To capture a long writing measure, teachers followed similar protocols to statewide Smarter Balanced Writing assessments. Teachers asked students to write an essay response to a selected prompt that was read aloud and printed for all students. Students were given a 5-minute organization and prewrite time, followed by 25 minutes of writing time. They could complete their prewrite on notebook paper provided to them. Students completed their writing response on a Google Doc. Teachers provided a five-minute and then a one-minute warning as time expired. All docs were submitted to a teacher file, which the teacher then moved to the researchers' files for scoring.

Smarter Balanced Performance Task Writing Rubrics (for grades 6–11) were used to grade long writing samples for quality. Project personnel selected rubrics developed by Smarter Balanced Assessment Consortium, a public agency that specializes in education assessment. Smarter Balanced assessment materials are aligned with the Common Core State Standards (CCSS) and are comparable to the Kansas State Department of Education (KSDE) Multidisciplinary Performance Task rubrics for grades six through eight.

Researchers use argumentative, explanatory/expository, and narrative Smarter Balanced rubrics to score student writing samples. While criteria in each of the rubrics vary according to genre specifications, all three

rubrics measure organization/purpose and evidence/elaboration on a four-point scale where “4” is the highest numerical score and “1” is the lowest numerical score. The third category, conventions, is measured on a three-point scale where “2” is the highest numerical score and “0” is the lowest. When assigning scores for each category, scorers consider the variety, severity, and density of errors according to grade-level CCSS requirements. Finally, if a student’s writing sample does not meet a category’s most basic criteria, it receives a score of “Not Sufficient” (NS). Student writing samples that receive a score of NS may be too short, off-topic, off-purpose, or not written in English. Scorers reference the Smarter Balanced scoring guide when scoring students’ writing samples. You can access the [full scoring guide](#).

Broader writing skills—the traits of *ideas and content*, *organization*, *sentence fluency*, *word choice*, and *conventions*—using longer writing assignments were assessed using independent *t*-tests for a sample of 63 WRITE students compared to 60 randomly selected students whose teachers were not in the WRITE group. The long writes happened near the end of the spring semester.

Technology Use Observation Procedure and Measure

Classroom observations were conducted to measure fidelity of implementation as well as to better understand the classroom environment in which the writing strategies were being used. The ALTEC Observation Form was modified for use as the data collection instrument in this evaluation (Craig-Hare et al., 2011). The sections of the observation form included categories for observing technology being used by teachers and students, how the students were grouped in various Learning Spaces during classroom activities, what the teacher was doing during the observation session, and what cognitive level, based on Bloom’s Taxonomy, was being implemented. Likewise, the tool includes items related to the Substitution, Augmentation, Modification, Redefinition Model (SAMR; Green, 2014). Designed to help teachers implement technology into classroom instruction, the four levels include: 1) Substitution: technology acts as a direct tool substitute, with no functional change, 2) Augmentation: technology acts as a direct tool substitute, with functional improvement, 3) Modification: technology allows for significant task redesign, and 4) Redefinition: technology allows for the creation of new tasks that were previously inconceivable (Hilton, 2016). For our purposes, the survey items specific to the SAMR Model sought to measure the effects of intentionally paired AT tools with evidence-based writing instruction.

Observations included momentary time sampling in live classrooms at 30-second intervals. Momentary time sampling has been shown to be an effective and accurate observation tool when short intervals are used and when the behavior is of substantial duration (Harrop & Daniels, 1986; Saudargas & Zanolli, 1990). In this case, the behaviors being observed in the classroom were not short or discrete behaviors occurring infrequently, they were general activities that would happen over a relatively long period of time during the classroom activities. In recording the observation data, the observer watched a single timer on a computer screen. Once the timer reached 30 seconds, the observer recorded what was occurring at that moment. Observation categories were scored every 30 seconds, with an overall rating for SAMR occurring at the end of the observation period. A sample of 22 treatment and 22 comparison classrooms were observed during the spring semester. Each classroom observation averaged 30 minutes in length, accounting for 1325 observation intervals in the treatment classrooms and 1295 observation intervals in comparison classrooms totaling 13,100 data points.

The analysis consisted of a weighted percentage calculated across classrooms. Rather than calculating percentages for each classroom and averaging the percentages, the total number of intervals in which a

specific category was scored in all classrooms was divided by the total number of intervals coded for all classrooms in each condition. For example, if there were five classrooms which have 0%, 0%, 2%, 3%, and 20% for teacher technology use, the average of these values would be 5%. This method, however, does not consider the length of the observation period. If the observation periods for the 0% scores were much shorter, then these should carry less weight when creating an average. By combining all observation intervals across all classrooms in a group, a weighted percentage can be calculated which differentially weights the length of the observation period.

Results

Short Write PM Results

Basic writing skills—word count, number of correctly spelled words, and number of words in correct sequence—were assessed for students in the WRITE group on two occasions: in the fall and in the spring. As shown in Table 1, all three skills increased significantly with small to moderate effect sizes.

Table 1: Paired-samples t-Tests for Basic Writing Skills

	Mean (Fall)	SD (Fall)	Mean (Spring)	SD (Spring)	t value	p value	d
Word Count	58.50	23.73	66.20	26.50	14.00	<.001	.31
Spelling	56.82	23.17	64.46	26.37	13.82	<.001	.31
Sequencing	55.63	24.56	63.16	27.47	13.50	<.001	.29

Note: N = 1,569

Long Write Results

Sixty-three students who received WRITE training in their classrooms were compared to sixty students who did not on the quality of their writing. Writing samples were scored on five traits: *ideas and content*, *organization*, *sentence fluency*, *word choice*, and *conventions*. Though students in the WRITE group had slightly higher scores on ideas and content and organization, there were no statistically significant differences between groups on the five writing traits. Table 2 shows the results.

Table 2: Descriptive Statistics for Writing Traits

Ideas and Content (I), Organization (O), Sentence Fluency (S), Word Choice (W), Conventions (C)

	Mean (I)	SD (I)	Mean (O)	SD (O)	Mean (S)	SD (S)	Mean (W)	SD (W)	Mean (C)	SD (C)
WRITE Group N = 63	3.51	1.00	3.57	1.00	3.19	.86	3.29	.94	3.43	.84
Comparison Group N = 60	3.33	.99	3.33	1.13	3.27	.88	3.23	.85	3.50	.83

Note: possible scores range from 1 to 6

Classroom Observation Technology Use Results

This category's purpose was to indicate if digital devices were used at the time of the observation. There were two subcategories that were coded, Teacher Technology Use and Student Technology Use. Teacher Technology Use was coded when the teacher was using technology as part of the class lesson or instruction. Student Technology Use was coded when any student was using technology during class, even if it was only one student using the technology. This category helps us understand if technologies are in use during a class

period and by whom. An independent-samples *t*-test was conducted to analyze instances where AT was being utilized by teachers. This test was significant for teacher ATG use, $t(42) = 4.94$, $p = 0.00$. Teachers in the treatment classrooms ($M = 38.91$, $SD = 21.64$) on average were observed using AT more than teachers in the comparison classrooms ($M = 10.82$, $SD = 15.56$) at the $p < .05$ level. The 95% confidence interval for the differences in means ranged from 16.62 to 39.56.

An independent-samples *t*-test was conducted to analyze instances where AT was being utilized by students. This test was significant for student technology use, $t(42) = 2.66$, $p = 0.01$. Students in the treatment classrooms ($M = 34.73$, $SD = 24.25$) on average were observed using technology more than students in the comparison classrooms ($M = 16.27$, $SD = 21.72$) at the $p < .05$ level. The 95% confidence interval for the differences in means ranged from 4.45 to 32.46. Statistically significant, teachers and students were observed using technology more in the treatment classrooms than in the comparison classrooms. See Table 3 for results.

Table 3: Independent-Samples *t*-Test for Teacher and Student Technology Use

	Mean Treatment Classrooms	SD Treatment Classrooms	Mean Comparison Classrooms	SD Comparison Classrooms	<i>t</i>	<i>p</i>
Teacher Technology Use	38.91	21.64	10.82	15.56	4.94	0.00
Student Technology Use	34.73	24.25	16.27	21.72	2.66	0.01

Note: n = 44 teachers and n = 1,569 students

Treatment & Comparison Classroom

Classroom observations reported significantly increased uses of technology for students and teachers in the treatment group and increased use of students creating new content in the treatment group. Students in the comparison group were observed in activities where they were applying knowledge more than students in the treatment group. With students using digital devices more in the treatment classrooms, it was encouraging that most of this time was beginning to be used for activities where students are analyzing and/or evaluating information or creating new content. In general, technology-infused lessons were observed primarily at the substitution and augmentation levels of the SAMR framework. Treatment classrooms, however, were observed with activities at the modification and redefinition levels more than the comparison classrooms. (See Table 4.) Most classrooms were observed utilizing technology for substitution and augmentation, or not using technology at all. The treatment classrooms, however, were observed using technology more often for modification and redefinition activities than the comparison classrooms.

Table 4: Percentage of Classrooms Observed at the Various SAMR Levels

	Treatment Classrooms	Comparison Classrooms
Redefinition	14.29%	0.00%
Modification	19.05%	4.55%
Augmentation	23.81%	9.09%
Substitution	23.81%	31.82%
No Technology being used	19.05%	54.55%

Note: number of classrooms = 44

Discussion

Assistive technology's role in SWD learning is critical. With the increased availability of technology devices and the way software, apps, and extensions are accessible if not embedded, technology is becoming ubiquitous as an essential resource or an educational material for all students, including SWDs. This is particularly represented in student writing where the post-pandemic K–12 learning environment increasingly utilizes a technology device in the student writing process. For SWD, access to the embedded supports offers a potential change in SWD access to and use of essential technology-based writing supports. The growing availability of AT tools, however, does not equal meaningful integration on the part of the SWD and their teacher.

The results of this study offer a glimpse into the need to combine effective instructional strategies with proven technology tools to further increase the use of essential technology tools for SWD and to impact learning outcomes (Graham & Harris, 2019). Assistive technologies, such as the ones used in this study, have been shown to impact the quantity and quality of students' writing (Graham et al., 2019a). The increased availability of these tools embedded within student devices offers potential growth in the use of essential AT tools for SWDs. Enhancing access to AT tools is often not enough (Graham et al., 2019b). Instead, combining the tool with an instructional practice may facilitate teacher use and subsequently, student use of the various tools increasingly available. Another factor for consideration is using student data to evaluate the ongoing progress in order to determine the extent to which current approaches to instruction are working. Using a progress monitoring system like that of WRITE particularly makes sense for evaluating the impact of the SRSD combined with a tech tool and subsequent student writing outcomes.

The results of this study are consistent with those of previous studies (Graham et al, 2019a) in terms of (a) positive effect on combining instructional strategies with technology tools to further technology implementation, (b) successful use of SRSD with technology supports to improve student writing outcomes, and (c) enhancing students' technology use through the support and guidance of instructional coaches. In addition, this study provides preliminary evidence that extends existing thought on ways to further facilitate the successful implementation of AT tools into the inclusive classroom setting. Even so, some would argue (Graham & Harris, 2019) that meaningful integration of AT requires an identification and consideration process followed by careful device selection, training, and implementation. The findings of this study suggest a successful application of various AT-based tools. The tools are focused on writing supports that feature effective instructional strategies as identified through data-based decision making.

Outcomes and Benefits

Combining effective instructional strategies with proven AT tools furthers teacher classroom integration of AT and improves student AT use and accompanying learning outcomes. Through supports like the Writing Classroom and tools such as the WRITE progress monitoring system, teachers can improve their technology integration efforts and students can increase strategy and AT use, leading to further empowerment in their individual writing experiences.

AT tools are increasingly available in digital devices populating our K–12 classroom. With increased student access to laptops, Chromebooks, and similar devices, AT tools (often embedded as apps or extensions) are by default available for student use. Growing access has addressed some of the previous barriers to SWDs' Assistive Technology Outcomes and Benefits |

AT use (e.g., budget to purchase AT software). However, simply providing the AT tool to the SWD does not equate to subsequent use, nor a positive impact of this use on SWD learning outcomes. Previous research has shown that meaningful AT access and use must be coupled with teacher understanding, support, and reinforcement to use the AT tools within the classroom's demands.

This study sought to understand how combining effective writing strategies with increasingly available AT tools would impact student AT use. More importantly, would the AT tools used in conjunction with effective instructional practices improve student writing outcomes? The growth in the availability of AT tools (e.g., word prediction) and the devices from which students can choose is potentially impacting the implementation of these AT tools to the benefit of the teacher and student. It seems essential to the effective use of these AT tools to align them to effective instructional strategies. While this study focused on one effective writing strategy (SRSD) and a series of three AT tools, the subsequent teacher and student use and the impact on student writing outcomes are both quite positive.

Examining the impact of effective writing practices with increasingly available AT tools is of particular interest since post-pandemic classrooms appear to have an expectation that students will draft, edit, and publish their writing via a digital device. These various digital devices, in turn, increasingly have apps, software, or extensions of the various AT tools that, when used, have been shown to improve the quantity and quality of student writing.

Future Directions

The exponential growth of technology tools to assist in student learning will only continue in this post-pandemic world. The expectation is not whether to use a laptop, Chromebook, or similar device but, instead, it is how and when the device will be used across the educational day. This is particularly relevant in writing instruction where students now are expected to begin and complete their writing process via a digital device. These digital devices are increasingly coming with embedded supports and tools that traditionally may have been referred to as AT tools but gradually are being used by all students, particularly SWDs. However, researchers have learned over time that simple availability or access to technology does not lead to meaningful integration on the part of the teacher nor, significantly the student. While access to technology may increase use, it does not necessarily mean it will be used in the way it was designed and, more importantly, used to further the learning outcomes of the individual. For SWDs, AT use also might be in question about the unique and specific application aligned with the individual's needs and unique to their disability. Instead, educators need to further consider ways to utilize this growing availability of AT tools in a meaningful and purposeful manner if they are to improve outcomes for individuals with disabilities.

As this study illustrated, one primary way of facilitating meaningful use of these growing AT tools is through the integration and combination of proven effective practices. The study highlighted effective writing interventions and combined them with the existing AT tools, because writing has become such a ubiquitous aspect when it comes to technology integration. By combining effective writing practices with technology use, teachers have a way of thinking about and using technology tools aligned with practices they have been aware of and implementing through previous instructional efforts. In this manner, the technology simply furthered their instructional teaching efforts, making the effort on the part of the teacher to combine increasingly available tools with instructional practices that already had merit for their implementation. The use of Writing Classroom and the WRITE progress monitoring tool was a way to systemize this integration,

offer direct instructional supports, offer examples, offer step-by-step user guides, and further facilitate understanding while demonstrating a crosswalk between the strategy and the technology. The expectation would be that future efforts combine proven instructional interventions across other areas of instruction (e.g., reading) with increasingly available and easily to implement assistive technology tools.

Declarations

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Voices from Academia

Impacts of an Assistive Technology Graduate Program: A Case Study

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Abstract

Alumni from an Assistive Technology (AT) graduate program were invited to complete a survey and participate in focus groups to share how they are using the knowledge gained from their graduate degree and its impact on their professional careers. The sample of 27 alumni spanned seven years and a variety of professional backgrounds. This qualitative single-case study revealed impacts on careers, professional skill development, and technology skills after graduation. Participants also connected this later skill development to their concrete learning experiences within the graduate program.

Keywords: assistive technology, graduate program, perspectives, special education

Introduction

The consideration of assistive technology (AT) is legally required when developing a student's individualized educational program or IEP (Peterson-Karlan & Parette, 2006). During an IEP meeting, special education teachers are typically expected to lead this consideration, although pre-service programs often don't provide enough AT in content-heavy educator preparation programs (Bausch & Hasselbring, 2004). Graduate programs focusing on assistive technology skills and knowledge have emerged to increase much-needed teacher capacity (Atanga et al., 2019; Bausch & Hasselbring, 2004; Mason, 2021). Arthanat et al. (2017) surveyed 318 assistive technology professionals (ATPs) and reported that "50% of the respondents felt less

than adequate to provide assistive technology services" (p. 793). However, the survey did not distinguish if the participants completed an AT-specific graduate program. When graduate students have AT incorporated in their graduate coursework, they feel more confident to implement technology practices in their teaching (Mason, 2021). Although there is limited research on the impact of these graduate programs and how this enhanced knowledge impacts a teacher's practice or career (Torrens & Asghar, 2023), this study contributes to the research within this area.

Target Audience and Relevance Section

The target audience for this article is higher education professors, program designers, special education teachers, and other service providers (occupational therapists, physical therapists, and speech and language pathologists). For higher education professors and program designers, the current study highlights the benefits of incorporating AT skills and knowledge within graduate programs for in-service educational professionals. It will also demonstrate the career and learning benefits to incorporating AT. For education service providers and special and regular education teachers, this research will highlight the benefits of in-service education around AT to enhance problem-solving, critical thinking, and specific technology skills. Raising the AT awareness with the educational field can directly benefit students and classroom practice. As Atanga et al. (2019) highlighted, when educators took at least one AT college course, they reported an increased proficiency and awareness in AT. This study contributes to the literature around the importance of AT-specific courses in graduate programs to build proficiency and awareness.

Assistive Technology

Assistive technology is defined in the Individuals with Disabilities Education Act (2004) as "any item, piece of equipment, or product system, whether acquired commercially off the shelf, modified, or customized, that is used to increase, maintain, or improve the functional capabilities of a child with a disability" (§ 300.5). In addition to AT devices, IDEA also describes AT services for schools, including evaluation of needs, purchasing, selecting tools, coordinating supports, and training on the technology (§ 1401). In a systematic review of satisfaction with AT service delivery, Ranada and Lidström (2019) identified the importance of AT team members to utilize a team-based approach, involve the user in the assessment process, use assessment protocols, and conduct follow-up training. These components impact the user satisfaction with the implementation of AT (Ranada & Lidström, 2019). However, lack of user involvement, challenges in acquiring a device, technological challenges, and changes in need may result in AT abandonment (Phillips & Zhao, 1993). Graduate programs focusing on AT address these specific areas to facilitate the use of best practices during the AT consideration, evaluation, and implementation process. What remains to be explored is what impact this graduate degree has on professional practice.

The need to increase AT knowledge and communication in the special education field is crucial (Arthanat et al., 2017; Atanga et al., 2019; Bausch & Hasselbring, 2004) and was further emphasized during the transition to virtual learning during the COVID-19 pandemic (Courduff et al., 2022). This study shares the variety of perspectives from educational professionals on how they are utilizing their knowledge within practice. The findings also provide additional guidance to graduate AT programs on valuable learning experiences and necessary skills/knowledge to improve professional practice.

Teacher-Graduate Program

Continued education for teachers and educational professionals is critical for the additional development of teaching strategies and professional practices (Maviş Sevim & Akin, 2021). Many states within the United States require a master's degree to obtain a professional certification (*Teaching requirements by state*, 2023). The Midwestern Higher Education Compact (MHEC) published a research brief on the "Impact of a Graduate Education on Teacher Effectiveness: Does a Master's Degree Matter?" Horn and Jang (2017) found a limited to unclear impact on student achievement for teachers with a master's degree compared to colleagues with bachelor's degrees. However, Horn and Jang (2017) suggest continued research on additional teacher and student outcomes of graduate degrees to capture all dimensions of impacts. This research aims to address teacher outcomes of a graduate degree in assistive technology.

Higher Education and Assistive Technology

Although the research on AT in higher education largely focuses on pre-service teachers (Jones et al., 2019; Keown & Colson, 2021; King & Allen, 2018; Laarhoven & Conderman, 2011; Michaels & McDermott, 2003; Park et al., 2022), additional research is emerging for graduate programs (Mason, 2021). Currently, a strong research base exists on building educational professionals' AT knowledge through professional development (Chmiliar & Cheung, 2007; Du & Lyublinskaya, 2022; Hurst & Tobias, 2011; Satsangi et al., 2019; Schladant et al., 2023; Torrens & Asghar, 2023). This case study shares alumni perspectives on the impact of their graduate program in AT on their practice and careers. In higher education, utilizing experiential adult learning theory can be linked to positive learning outcomes and impacts on practice (Diep et al., 2019; Jackson & Macisaac, 1992).

Kolb Experiential Learning Theory

Kolb's Model of Experiential Learning (1984) was utilized in this study as the theoretical framework to guide the focus group questions and to analyze the transcripts and survey responses. Kolb's Theory emphasizes learning as cycles of experiences and reflection. The four key phases are: concrete experiences, reflective observation, abstract conceptualization, and active experimentation (Kolb, 1984). The following definitions of the phases were utilized:

- *Concrete Experience*: Where the learner is actively experiencing an activity.
- *Reflective Observation*: Where the learner is consciously reflecting back on that experience.
- *Abstract Conceptualization*: Where the learner is being presented with/or trying to conceptualize a theory or model of what is (to be) observed.
- *Active Experimentation*: Where the learner is trying to plan how to test a model or theory or plan for a forthcoming experience (Jenkins 1998, p. 43 as cited in Healey & Jenkins, 2000, p. 187).

Kolb's framework was chosen because it captures the learning philosophy and foundation of the AT program within the study. This framework assisted the analysis of participants' reflections on their learning experiences and applications within their current experiences.

Research Questions

This qualitative case study focused on the following research questions:

- What impact, if any, does a graduate degree in assistive technology have on professional practices?

- How are graduates of an assistive technology graduate program applying the knowledge learned in their practice?
- What learning experiences within a graduate AT program influence professional practice?

Context: AT Program Information

Within the graduate program, there were five core AT courses: Introduction to AT, AT for Reading and Writing, AT for Students with Multiple Disabilities, AT Assessment, and an AT Practicum. The school-based practicum immersed the graduate students in an extended school year program within a special education school. Graduate students completed assistive technology evaluations and provided implementation activities with two different K–12 students. One K–12 student had physical access challenges and the other K–12 student had learning challenges. The 2019/2020 academic year was an outlier because half of the spring semester was held online as a result of the 2020 COVID-19 pandemic. Due to social distancing and safety protocols in place, the 2020 summer practicum conducted AT evaluations virtually. The graduate students applied the strategies and skills they learned in their in-person classes to a virtual evaluation environment with members of the community. All other semester course offerings were hybrid classes with a mixture of online and on-the-ground experiences.

Continuous Updates

The field of technology rapidly changes, and therefore, the course content also needs to reflect the changes in the field. The foundational concepts within the courses are more theoretical, for example, applying the SETT Framework (Zabala, 2005) to focus on the student (or person), environment, task, and then the tool. This framework aims to avoid buying or implementing technology that isn't aligned to an individual's needs. Courses also addressed effective consultation practices to promote implementation of assistive technology, general troubleshooting techniques, and technology analysis. Beyond these foundational concepts, the instructor continuously updates the specific tools/resources that are demonstrated or explored within the courses. Remaining updated and relevant within the field is crucial. The instructor attended AT conferences, participated in webinars, engaged with social media, and belonged to various listservs to ensure course content reflects the technology available in the field.

Course Feedback Cycle

The university administered end-of-semester course evaluations asking students to reflect on their experiences and effectiveness of courses throughout a student's program. In addition to the final course evaluation surveys, the instructor administered anonymous midterm surveys to gauge learning experiences and to make mid-semester adjustments as needed. Some adjustments that have been made throughout the years based on student feedback are more access to full versions of tools, incorporating student case studies, adding augmented reality, addressing technology for employment, and more. Including student feedback within course development is integral to the program's success. The continued feedback cycle ensures that instructors are continually responding to student needs, incorporating them in the learning process, and meeting the standards of the field.

Methods

This qualitative case study focused on recent graduates of an AT program in the northeastern United States. After acquiring Internal Review Board (IRB) approval, the survey and virtual focus group invitations were sent

to 47 alumni of an AT graduate program. Twenty-seven participants completed the survey responses (57% response rate) which included basic demographic information and three open-ended questions. The survey questions are included in Appendix A. Three rounds of virtual focus groups with nine total participants were also completed; the focus group protocol is included in Appendix B. The focus groups were held virtually to provide flexibility in scheduling for the participants, then recorded and transcribed.

The purpose of the initial survey was to gather current/past employment information and general question responses from alumni, and to recruit participants for the focus group. The survey responses were also utilized to corroborate the focus group discussions. There were 18 more perspectives shared within the surveys which provided a broader perspective on the impacts of the graduate program. However, the focus groups allowed the research to ask follow-up questions and have participants elaborate on statements, perspectives, and opinions, adding much needed dimension to the survey responses. The initial survey responses were also used to ask follow-up questions or clarify experiences within the focus group.

The focus group transcripts and open-ended survey answers were initially coded using structural coding (Miles et al., 2018) to identify themes between the survey and focus group responses. A thematic analysis (Spradley, 1979) was then conducted after the first round of coding. During the second round of coding, the focus group responses around participants' experiences within the program were analyzed. Kolb's Experiential Learning Theory (1984) was utilized as the analysis framework with the goal of conceptualizing the learning that occurred within the AT program and subsequent professional applications.

Participant Information

The 27 participants were asked to provide their current roles and year of graduation. Table 1 depicts the participants' current roles after graduation. The largest group of alumni were special education teachers (12/27, 44%) and next were AT Specialists (4/25, 15%). Table 2 displays the graduation years of the participants. Two participants graduated in 2015 or earlier and the remaining 25 graduated between 2016 and 2023, with the largest group from 2023 (26%). Additional demographic information was not gathered from the participants because it was not directly relevant to the research questions.

Table 1: Participant Current Positions

Current Role (After Graduation)	Frequency
AT Specialist	4
Special Education Teacher	12
Accommodations Specialist (Higher Ed)	1
Regular Education Teacher	2
Literacy and Numeracy Specialist	1
Speech and Language Pathologist	3
Paraprofessional	1
Unemployed	1
Technology Integration Support Specialist	1
Private Consultant	1
Total	27

Table 2: Year of Graduation

Year of Graduation	Frequency
2015 or before	2
2016	1
2017	2
2018	3
2019	2
2020	3
2021	2
2022	5
2023	7
Total	27

Findings

The findings from the survey and focus group data revealed three main categories: employment, career and/or practice, and learning experiences. The explicit employment impacts (shifting or changing positions) were not as significant as the impact on career and professional practices. Within this category, participants shared that they implemented assistive technology in their practice, improved professional skills, and adopted high-quality instructional practices. The next stage of coding focused on the participants' reflections of the learning experiences within the program and the perceived impacts of those experiences. Using Kolb's Theory of Experiential Learning as a framework, the two main areas were concrete learning and reflective observation. Participants most frequently reflected on the concrete learning experiences within the program and the impacts on their professional practice.

Impact on Employment

The survey questions (included in Appendix A) asked participants to report on any career changes. Since graduation, 9 of the 27 participants (33%) reported transitioning to new positions incorporating AT and also shared that their AT graduate work was influential during the hiring process and directly resulted in their new positions.

Impact on Career and/or Practice

For the initial rounds of coding, structural coding (Miles et al., 2018) was utilized. The transcripts for the focus group and the qualitative survey responses were both analyzed. Responses to questions were initially coded based on the question. The codes were then categorized into specific groups and combined into three major themes. Table 3 includes the emerging themes and ancillary codes to provide dependability and transparency within the qualitative analysis (Anfara et al., 2002). The three major themes of responses regarding the impact on practice were: AT practice application, professional skill development, and high-quality instruction.

Table 3: First Round Code Categories

Theme	Initial Code
AT Practice Application	AT skill development (20) Application of SETT framework (11) Application of AT for special education teacher (11) Application of AT for regular education teacher (2) AT in the IEP (1) Application of AT in higher education (1)
Professional Skill Development	Problem solving (11) Increased confidence (11) Advise colleagues (6) Learned collaboration/built community (5) Report writing (3) Knowledge of funding (1) Leadership (1)
High Quality Instruction	Consistently using resources from class (13) Access to technology (10) Instructor passion (5) Class progression (2)

AT Practice Application

The most frequent theme of responses was categorized as AT practice application. Participants were asked how they were using the specific knowledge or skills from the program, and to provide examples. The largest area, appropriately, was AT skill development. Participants cited examples of using text-to-speech, speech-to-text, implementation vs. access, sentence starters, modeling, and visuals/symbols. Next, participants referenced the SETT framework by Joy Zabala (2005), a decision-making tool widely utilized within the AT field. SETT stands for student, environment, task, and tool. This framework is referenced in every course to guide AT tool feature matching for individuals. Many alumni specifically referenced using the SETT framework in practice. Others shared their thinking and application which revealed their application of the framework:

So, what I found really interesting though, is the stuff that I learned because I did work with kindergarteners and first graders and all that and but it really doesn't matter what age they are. It's the like figuring out how to use the technology and how to make it effective and figuring out the right tool for the task remains pretty consistent.

In this quote, the participant is sharing an experience, but the thinking revealed within the quote is applying the SETT framework process. The special education teachers ($n = 12$) reported the most implementation of AT skills.

Professional Skill Development

The next theme was professional skill development. Participants most frequently shared examples of problem solving (11) when asked about how they apply the knowledge from their degree. For example, one participant shared "My AT degree has me thinking about ways I can use AT to help my students that I may not have thought about before." Another shared an anecdote about programming an augmentative and alternative communication device (AAC):

So, I programmed my student's AAC device to work with Google. But I found out that I have to record my voice to say, 'Hey, Google, what's the weather for today?' I had to program his device to say that. But then he pushes the button, he knows where to find the 'Hey, Google' page so he pushes that button. And then he has all these different things that he can ask Google to do, and he just loves it. He has the power to do something.

A variety of other examples were provided where participants shared problem solving scenarios around funding, virtual learning, accommodations, and more.

High-Quality Instruction

The final category was high-quality instruction. When asked about their learning experiences within the AT program, participants provided a variety of examples of how the program impacted their learning. The highest frequency of responses was consistently using their resources from class in practice. For example, in the Introduction to Assistive Technology course, one assignment is to create a LiveBinder with links to the resources reviewed. Multiple participants referenced using their LiveBinder in practice to remember tools and resources. Many alumni also highlighted the value of having access to a wide variety of technology within the program as well. The program is held on campus at a center for assistive technology with computers, iPads, Chromebooks, a variety of switches, and an eye-gaze system to be utilized within the program. Other codes included within this category included instructor passion and class progression. One participant stated:

I liked the way the program was structured. The majority of our classes were held in person. This really helped me to be able to utilize the specific technologies that we were discussing in class and get real-time feedback from my professors. I do not feel that if we were virtual or hybrid that I would have been able to grasp things as well as I did, nor would I have felt as comfortable with the technologies that we trialed.

Organizing information appropriately through course sequences is a key principle of higher-education learning (Ambrose et al., 2010; Groccia & Buskist, 2011). Application of class activities allows students to “develop learning mastery by acquiring component skills and practice combining and integrating” (Groccia & Buskist, 2011, p. 9), which is another research-based principle of adult learning in higher education (Ambrose et al., 2010). These learning experiences translate into alumni's practice application.

Program Learning Experiences

The second stage of coding focused on the categorizing of the learning experiences shared during the focus groups and qualitative survey responses. Kolb's Theory of Experiential Learning was utilized to analyze the participants' responses. Only two of the categories emerged during the analysis: concrete experience and reflective observation. Since the responses were post-learning experiences, abstract conceptualization and active experimentation did not align with the context.

Concrete Learning Experience

Concrete learning experiences were referenced most frequently where the learner is actively engaged during an experience. Many participants referenced the impact of the school-based practicum on their technology and professional skill development. One participant stated:

I think that actually, [out] of all my classes in my graduate degree they were the most hands on and, like, real life, you know, like, stuff that like I could take away and actually use? Um, I definitely still use some of the programs. And I don't know, I mean, I don't feel like where I'm at that they give us a lot of opportunities to use stuff. But I'm on my own, especially now that everyone has computers, it has made a little bit easier.

Another participant shared positive experiences with the school-based practicum:

The practicum was my piece that was the best. Because we were able to see like two different perspectives of it. So, we were with the students who needed switch access and we also worked with a student who just needed reading support. So being able to balance both pieces. I don't work with kids who, you know, that needs switch access right now. But I do work with the students who need the reading and writing support. So being able to do that has definitely helped.

The concrete learning experiences were the most frequently referenced throughout the focus groups and surveys.

Reflective Observation

When applying Kolb's Framework, some participants demonstrated reflective observation regarding their learning experiences. For this study, reflective observation was applied when the learner consciously reflected back on that experience (Jenkins 1998, p. 43 as cited in Healey & Jenkins, 2000, p. 187). There were five instances where participants demonstrated reflective observation when they reflected on specific course activities. Although the general question prompted participants to share their learning experiences that lend to reflection, the code was applied when the participant provided a deeper reflection on their learning. For example, one participant who graduated before the others in the focus group shared the differences in her experience:

The thing that was most missing when I was there, and I was there the longest ago out of this group isn't as much hands-on and as much as the technology. I really think that you have to have the iPads available, and you have to have the different the Mac [sic] versus the PC available for you to truly feel comfortable. You're never going to know it all...That was the one thing that was I thought missing. Yeah. But I thought the general instruction on the whole was really well done. And the classes were really informative, except for the hands-on experience. I felt confident, like my tasks analysis and all those things like all the things you needed to learn in order to do an evaluation. I felt the only thing really missing was enough access to the different technology before you were actually using it.

This participant did not have as much access to technology and was in the program before some of the tools were incorporated. Others reflected on specific courses and assignments.

Limitations

Limitations should be considered when reviewing the findings of this study. First, the small sample size at one university affects the generalizability of the impacts of an AT graduate program. Also, the researcher is also a faculty member within the AT graduate program, which could have brought influence on the discussions within the focus groups. The emergency transition to online learning during the COVID-19 pandemic also likely impacted the participants' learning experiences within the program. Finally, the perspectives of the other alumni were not represented since they didn't complete the survey or participate in the focus groups.

Discussion

The findings demonstrate that the value of an AT graduate degree program lies not only in job acquisition but also in the technology and professional skill development. When reflecting on the impact of their program, participants not only reported building specific assistive technology skills to implement with students, but also equally reflected on the importance of the development of their professional skills. Many participants elaborated and provided specific examples of problem solving, collaboration, and increased confidence within their careers as a result of the experiences within their AT graduate programs. One of the most frequent examples of impact was advocating for students' needs in regard to AT using the SETT Framework (Zabala, 2005) as a tool. For example, one participant highlighted the overall impact of the SETT Framework in practice:

I think the SETT was very helpful. I didn't realize it when I was doing it. But then later on, when people would ask me, I would come to that, well, you should look at this. And the SETT really seemed to give a lot of good guidelines for some of the recommendations I made and why I made those recommendations.

Correlating with the skills they developed after graduation, participants also reflected on their learning within the program. The major theme discussed was the impact of the concrete experiences within the program—the school-based practicum and hand-on technology classes. Similar to the work of Maviş Sevim and Akin (2021), the alumni were also interested in continued opportunities for learning experiences and connection with the content. Participants connected the development of their problem solving, technology, and collaboration skills within their careers. The SETT Framework (Zabala, 2005) was frequently referenced as helping participants confidently advocate and problem solve for their students. Utilizing this framework during concrete experiences within their courses built the capacity to continue its use in the field to also reinforce professional and technical skills.

Alumni cited a variety of concrete learning experiences as the most impactful within their program. As Ambrose et al. (2010) highlight, to establish mastery, “students must acquire component skills, practice integrating them, and know when to apply what they have learned” (p. 95). Participants' reflections on their implementation of AT and professional skills imply their mastery of AT principles and skills through concrete learning experiences within the program. Increasing teacher capacity in the area of AT is crucial to meet students' needs (Atanga et al., 2019; Bausch & Hasselbring, 2004). The current study also revealed that an AT program with in-person, concrete experiences can increase teacher professional skills in the areas of problem solving and collaboration.

Outcomes and Benefits

As the field of AT grows, with it comes opportunity. When “online assistive technology graduate course” is searched online, nine programs are immediately populated in addition to a multitude of online individual courses and modules. Tracking the outcomes and benefits of the investment in higher education is important for potential applicants to make the best decisions on their educational investment. As Atanga (2019) posited, a need has been identified by special education teachers to increase AT training in college courses, and the availability of these programs is a significant advancement in opportunity. Ensuring that impactful and effective learning experiences are incorporated within these courses is crucial for programs. Although a small case study, the participants emphasized the educational benefits of hands-on projects with technology. Some of these experiences can be replicated in an online course, but many required in-person access to specific technology, such as 3D printers, iPads, and VR headsets. In addition to the in-class activities, the participants reflected on the powerful learning experiences within the practicum. The learning activities can be beneficial starting points for instructors or program designers to maximize effectiveness of courses.

The current case study highlights that structured, graduate coursework can positively impact professional practice of a variety of educational professionals. Special and regular education teachers reported increased confidence in implementing assistive technology, which can result in increased access and implementation for many students. Successful implementation of AT is linked to staff training (which can be through graduate coursework) and implementation of AT devices (Coleman & Cramer, 2015). Increasing access to graduate coursework for all educational professionals can increase their confidence which can positively impact AT implementation (Flanagan et al., 2013). Higher education programs and educational professionals should strongly consider the positive benefits and outcomes of graduate coursework in AT.

Future Research

Future research opportunities include tracking the implementation and student impact of AT use by individuals with AT graduate coursework. Tracking the impact through student learning is the next step in this process. There should also be continued investigation of meaningful graduate learning experiences within AT programs linked to learning outcomes.

Declarations

This content is solely the responsibility of the author(s) and does not necessarily represent the official views of ATIA. No financial disclosures and no non-financial disclosures were reported by the author of this paper.

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Appendix A

Survey Questions

1. What year did you graduate?
2. What program did you complete?
3. What was your position while you were in the AT program?
4. What is your position now?
5. If you transitioned positions, did your degree have an impact on your new position? How?
6. How do you think your AT degree has impacted your teaching practice/career?
7. What would you change about the AT program... the content covered and/or the classes? Why?

Appendix B

Focus Group Protocol

As the participants are joining the password protected Zoom, the researcher will facilitate informal conversations to get everyone talking in preparation for the focus group (Krueger & Casey, 2015). Some examples are:

- How is everything?
- What has been going on since graduation?
- How is your school year going? What is new?

Ask for verbal consent to record the focus group.

Ask the participants to go around, share their names, teaching positions, year they graduated, and program.

- *Question #1:* What were your experiences in the AT program? Reflect on learning experiences.
- *Question #2:* How are you using the knowledge and skills from the AT program in your professional practice? Can you provide a specific example?
- *Question #3:* What impact has your AT degree had on your career?
- *Question #4:* What would you change about the AT program given your experiences?

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Voices from Academia

Assistive Technology Training in Transition Programming

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Abstract

Individuals with intellectual disabilities are employed at lower rates than those without disabilities and evidence supports the use of assistive technology (AT) devices to improve vocational outcomes for this population. This feasibility study investigated the impact of AT training to establish a framework to guide secondary transition programming and research. The results offer valuable information to inform decisions about further training and interventions. This guidance aims to enhance the capacity for quality AT service delivery for young adults transitioning into work roles within this program. Successful implementation of person-centered AT problem-solving and decision-making could positively impact the integrated employment options and opportunities for young adults with intellectual disabilities.

Keywords: secondary transition, vocational skills, assistive technology, special educators, occupational therapy, intellectual disability

Assistive Technology Training in Transition Programming

Meaningful work provides individuals with benefits beyond monetary incentives. Work opportunities influence one's well-being and quality of life and are identified as social determinants of health (Office of Disease Prevention and Health Promotion [ODPHP], n.d.). For individuals with intellectual disabilities (ID), the benefits can also encompass feelings of self-sufficiency, greater self-worth, and a strong sense of purpose (Damianidou et al., 2019; Lanchak et al., 2023). In addition to these gains in personal growth, integrated work opportunities also allow individuals to more fully participate in their communities, building their friendships and sense of societal belonging (Carter et al., 2023; Voermans et al., 2021). Individuals with ID experience significantly less opportunity for meaningful work, an occupational justice issue inhibiting their inclusion and integration into their communities (Awsumb et al., 2022; Wehman et al., 2018). Individuals with disabilities continue to be much less likely to be employed than their non-disabled peers, across all age groups (United States Department of Labor Bureau of Labor Statistics, 2023). According to Winsor et al. (2022), only 18% of individuals with ID experienced integrated competitive employment. Individuals with ID face many obstacles to meaningful work. These can be negative attitudes and expectations from employers (Ali et al., 2010; Bonaccio et al., 2019; Kocman et al., 2017; Riesen & Oertle, 2019), as well as other factors such as limited skills and ability impacting proficiency with job tasks (Carter et al., 2023; Li, 2004).

Assistive Technologies (AT) can be powerful health-promoting tools to increase independence with tasks, maintain engagement in meaningful occupations, and promote inclusion (AOTA, 2016; World Health Organization, n.d.). AT is "any item, piece of equipment, or product system, whether acquired commercially off the shelf, modified, or customized, that is used to increase, maintain, or improve the functional capabilities of a child with a disability" (Individuals with Disabilities Education Act (IDEA), 2004). Federal special education legislation identifies the important role that AT plays in improving accessibility and educational outcomes for students with disabilities. The IDEA requires educators to consider assistive technology devices and services and to provide it for students who need it to achieve their special education and academic goals. AT can be critical in the life of a student with a disability by helping them to overcome barriers in the curriculum and provide them with access to their activities (Bowser et al., 2015).

According to Bowser et al. (2015), school systems struggle to address AT policy and develop systems that proficiently address student AT needs. They based *Quality Indicators for Assistive Technology: A Comprehensive Guide to Assistive Technology Services* on this application gap, providing guidance to school personnel with a structure containing important AT service areas and specific high-quality indicators to consider in each area. The purpose of this pre-experimental study was to address AT training and application gaps (Ault et al., 2013; Boot et al., 2018; Murray & Rabiner, 2014; Noll et al., 2006; Ripat & Woodgate, 2017) between policy and application of quality AT service delivery among special educators working with secondary transition program students. Its aim was to determine the impact of professional development trainings in the consideration, assessment, and documentation of AT devices and services for transition-aged students with IEPs. It is the hope that successful implementation of person-centered AT decision-making will positively impact the integrated employment options and opportunities for young adults with ID.

Target Audience and Relevance

The target audience for this paper includes AT practitioners, special educators, and related service providers aiming to build capacity among a group of special educators, supporting their perceived knowledge, skill, and Assistive Technology Outcomes and Benefits |

application of AT as a path to improved vocational outcomes for students with ID. This study supports the empowerment of teachers and students. Knowledge contributes to one's self-perception of competency. Not only does this training promote confidence in the AT consideration and problem-solving process among special educators, but this work seeks to help young adults see themselves as unique individuals with the opportunities to make choices in their occupations by expanding their abilities to complete work tasks through the use of adaptive equipment and technology.

Literature Review

This preliminary work identified few scholarly studies specific to the utilization of current technology use among young adults with ID in pre-vocational educational settings; however, studies validate the potential benefits of general consideration of and specific AT use among individuals with ID in the attainment of meaningful, lasting, integrated employment. Three themes emerge in the literature pertaining to individuals with ID seeking integrated employment opportunities: integrated employment factors, AT potential, and AT training and application gaps. The need for self-determination skill development among this population is a common thread throughout the literature review.

Integrated Employment Factors

The research available to review on the perspectives of individuals with ID in the workplace suggests both employment motivation (Kocman & Weber, 2018) and perceived obstacles (Ali et al., 2010; Li, 2004) in their vocational pursuits. Kocman and Weber (2018) reviewed the literature on job satisfaction and work motivation among individuals with ID. Employees with ID were found to have higher job satisfaction levels across different settings when compared to workers without ID. It was also reported that individuals with ID that were happy in their jobs tended to stay because they did not feel they had many employment alternatives. Li (2004) interviewed working adults with ID and found that many worry about job possibilities because of factors including insufficient work skills and qualification and discrimination. Ali et al. (2010) studied the attitudes and perspectives of individuals with disabilities about work using the 2006 General Social Survey, a tool to measure demographic characteristics and opinions of Americans age 18 and older. It revealed that individuals who are blind, have low vision, hard of hearing, deaf, wheelchair users, and those with cognitive disability, have similar job experiences as persons without disabilities and value the same characteristics of being part of the working community. They reported that individuals with disabilities express a high desire for working but are less likely to be searching for work than their non-disabled peers. This is reportedly due to lower levels of optimism about finding the right job fit. Ali et al. (2010) suggest that individuals with disabilities may feel that their disability may impact their productivity and that fewer jobs are available to them. They also suggested that they feel less optimistic regarding employment due to negative impressions of potential employer attitudes, such as prejudice, discrimination, and unwillingness to make accommodations for them (Ali et al., 2010). Voermans et al. (2021) interviewed individuals with ID working in integrated work settings and reported that the participants had a strong work ethic and focus on future goals. These individuals feel that they gain social value through their competitive employment. However, despite their sustained work opportunities, they experience stigmatization and report feeling as though coworkers and supervisors often underestimate their capabilities, making them feel dependent.

When investigating the disadvantages that individuals with ID face when looking for work, it is important to consider the views and perspectives of potential employers. Riesen and Oertle (2019) surveyed employers and found that they were open to developing work-based learning opportunities for persons with ID but had

concerns that included work potential. This work revealed misconceptions about the abilities of this population. Similarly, Kocman et al. (2017) found that employer's perceived lack of ability or skill was the most significant hesitation to hiring an individual with ID. Their study revealed that employers consider more barriers for hiring persons with ID and mental disorders than persons with physical impairments. Bonaccio et al. (2019) explored employer concerns throughout the employment cycle. Their work discusses many preconceived notions related to hiring individuals with disabilities in general, such as inability to perform tasks, lower productivity, needing expensive accommodations, safety, and not socially fitting in with coworkers. They address the common hiring hesitation related to potential accommodation costs, explaining that they are often overestimated, they are typically cost-effective, and the accommodations are often less expensive than not providing the accommodation.

Foley et al. (2012) describe transition as "the crucial task of moving from the protected life of a child to the autonomous and independent life of an adult" (p. 1747). Evidence supports the importance of self-determination among individuals with ID and its relation to quality of life (Duvdevany et al., 2002; Foley et al., 2012; Hui & Tsang, 2013; Wehmeyer & Palmer, 2003).

Self-determination involves the application of knowledge, skills, and beliefs to engage in goal-directed and independent decision-making (Hui & Tsang, 2013). It is considered critical in this transition to adult life as it is highly linked to positive outcomes in many areas of life, including employment (Duvdevany et al., 2002; Foley et al., 2012; Wehmeyer & Palmer, 2003).

Assistive Technology Potential

Studies have shown that AT allows individuals to perform tasks they would otherwise not be able to do, thereby increasing levels of self-determination by promoting the use of self-taught skills (Damianidou et al., 2019). A significant amount of evidence supports AT use among this population and its potential to improve outcomes. Damianidou et al. (2019) updated a meta-analysis evaluating the impact of technology on employment for individuals with ID and developmental disabilities (DD). They concluded that applied cognitive technology supports individuals with ID and DD in the achievement of positive employment outcomes. Differences were noted between groups with differing levels of disability, and significantly higher scores were noted when the technology used incorporated universal design features. Common mainstream devices such as smartphones, desktop and laptop computers, portable video prompting devices, augmented reality, and vibrating watches with visual prompting were discussed as examples of technology supports that improved task performance with less support from other people (Damianidou et al., 2019).

Video modeling is firmly established as an evidence-based intervention among individuals with autism spectrum disorder with and without ID. Using video models as technology supports has been found to improve skills and independence in instrumental activities of daily living (Campbell et al., 2015; Goodson et al., 2007; Mechling et al., 2009; Rehfeldt et al., 2003), on-task behavior (Coyle & Cole, 2004), and vocational skills, such as cleaning (Van Laarhoven et al., 2009), emailing (Fontechia et al., 2019), and complex shipping tasks (Burke et al., 2013). Schlosser et al. (2017) evaluated the use of the Apple Watch® as a universally designed tool to support children with ID and autism by providing just-in-time visual supports. Their study concluded that the provided scene cues on the Apple Watch® display resulted in successful direction-following. Gentry (2015) employed a case study, finding that implementing an individualized approach to using a mobile device as AT bolstered memory and independence for an individual with cognitive-behavioral challenges. Similarly, Allen et al. (2012) found audio cueing to have great potential to support adolescents with ASD and ID working

in product promotion, wearing *Walkaround*® costumes in a large discount retail store. These studies are relevant to this inquiry as they provide types of technology to consider for a variety of work settings as well as the increased benefit of considering AT with universal design features.

Training and Application Gap

Boot et al. (2018) used a systematic international literature search method to identify barriers and facilitators in the provision of assistive products (AP) to individuals with ID. Recurring barriers included cost, lack of AP awareness, and insufficient assessment. Potential facilitators were identified as an increased awareness and education regarding AP and the benefits for individuals with ID.

A qualitative research study designed and implemented by Ripat and Woodgate (2017) gained information from young adults with disabilities about their experiences using AT in support of their productivity. In this study, productivity-focused young adult occupations were identified as school-related tasks, postsecondary education, and volunteer or paid work. Using semi-structured interviews and a photovoice method, the researchers were able to better understand the significance of AT in the lives of the participants. Throughout the study, the participants promoted their AT use as necessary and significant to their participation and independence with their productivity pursuits, whether it was school or employment. The authors discuss the importance of employers recognizing the essential role of AT in enabling some young adults to effectively engage in their work responsibilities and contribute to the development of inclusive work environments. While this study did not include individuals with ID, it is relevant to this work. Specifically, it demonstrates a need to address the challenges that individuals face when transitioning from school-based services to employment as it relates to self-advocacy skills and problem-solving abilities. This study highlights the importance of self-determination and the role that special educators play in preparing students for work roles by using an individualized or person-centered approach to finding the right AT to match student needs. It also highlights the need for developing student self-advocacy skills around these accommodations for when they need to advocate in other settings, such as a new work environment.

Literature supports the need for increased AT training among professionals working with individuals with disabilities (Ault et al., 2013; Murray & Rabiner, 2014; Noll et al., 2006). Vocational rehabilitation counselors are involved in the service delivery and supports for transition-age students with disabilities. This study relates to the topic and identifies a need for support and training in AT consideration when working with transitioning individuals. Through survey methods, Noll et al. (2006) found that vocational rehabilitation counselors view AT as cost-effective solutions that positively impact employment outcomes for individuals with disabilities. Additionally, the counselors felt confident in the coordination, purchasing, and follow-up involved in providing AT service delivery. However, they reported a lack of confidence in the identification of need for AT. The results of this study suggest that training is needed to develop competencies around AT consideration. In another study, Ault et al. (2013) investigated the implementation of AT in rural schools throughout six states, finding that the use of AT devices was lower in rural areas. The most significant barrier to effective AT service delivery was identified as a lack of training for teachers. Additional factors were identified as lack of funding, lack of time, and lack of prompt delivery of services and devices. While teachers felt they had access to AT, they reported needing more training on its use.

Giulio E. Lancioni, a recognized expert in assistive technology, writes about assistive technology for people with DD. In 2017, Lancioni highlighted a variety of positive outcomes related to technology use, including those such as memory aids and video-enhanced presentation of multiple-step tasks. Lancioni considers

intervention programs as the most important factor in using AT solutions with success. He speaks to the need for deliberate expansion and development of programming focusing on AT intervention to improve its application in practical settings, such as pre-vocational and vocational environments (Lancioni, 2017).

This literature review provided foundational aspects of the current study. A synthesis of AT potential aspects and training and application gaps along with employment factors served as the basis in the development of survey and training methodology. The literature gaps reinforced the need for the study. The objectives of this preliminary study were to determine if program-specific AT professional development trainings increased special education teacher-reported application in the areas of AT consideration, AT evaluation, team AT collaboration, and AT documentation in IEPs. Additionally, it evaluated the impact on teacher confidence levels related to AT.

Methods

Setting

This feasibility study took place with a group of special educators in a midwestern city at a tri-district secondary transition program for 18–21-year-old individuals with disabilities. The goal of the site-based secondary transition program is to teach and support young adults in three areas of transition: employment skills, postsecondary education, and independent living. The special education program had 30 students enrolled, with three case managers coordinating, facilitating and implementing their center-based IEP programming at the time of the study. This selected setting allowed for the examination of the effect of AT training on the programming for individuals at a vital time in their lives when they are developing their job skills with a special education team of support. Eastern Kentucky University Institutional Review Board approval (#003669) was obtained prior to the start of the study.

Participants

The inclusion criteria for this preliminary study were special education teachers/case managers employed in the aforementioned tri-district secondary transition program. This included three full-time employees with special education licensure and training to work across multiple disability areas. In addition, one of the special education teachers is licensed as a work-based learning coordinator. Recruitment emails contained a written explanation of the study and the digital pre-training survey. Additional program staff, such as non-licensed paraprofessionals, were excluded in this early stage of investigation.

Procedures

Pre- and post-training surveys were developed using Qualtrics, an online survey instrument. This software allowed for digital distribution and multiple options for the descriptive analysis of data. The survey was divided into three sections: assistive technology consideration, assistive technology evaluation, and assistive technology documentation. The survey questions were primarily adapted from *The Self-Evaluation Matrices for the Quality Indicators in Assistive Technology Services* (Bowser et al., 2015). These quality indicators were designed to assist educational teams in decision-making to ensure comprehensive and high quality AT service delivery. Each section of the survey included several questions using Likert-like scale responses and one open-comment question to elicit more qualitative information. The survey consisted of 14 questions. In an effort to reduce bias, the surveys were anonymous, questions were worded clearly and simply, and options for responses were not influencing. After the participants were provided with details about the project and

information regarding their voluntary participation and confidentiality, they completed the pre-training survey. The survey can be found in Appendix A.

Two one-hour professional development sessions grounded in the literature and content expertise of the first author followed the pre-training surveys four weeks later. Due to the COVID-19 pandemic, the intervention trainings were presented in a live virtual format using Google Meet. These synchronous sessions allowed for discussion and questions throughout.

The aforementioned *Self-Evaluation Matrices for the Quality Indicators in Assistive Technology Services* (Bowser et al., 2015) guided the development of the AT professional development training for the special educators, in addition to The Student, Environment, Tasks, and Tools Framework (SETT; Zabala, 2005). The training content included legislation and policy as it relates to AT, district-specific guidelines, procedures, and supporting documents, as well as case studies to practice the AT consideration process. The SETT Framework served to provide structure to case study decision-making, illustrating how to effectively match AT to individual need, taking aspects of the student, their specific pre-vocational and vocational environments, and tasks into consideration when making AT tool decisions (Zabala, 2005).

Teachers were provided with six months of time to implement what they learned prior to completing the post-training survey. Descriptive statistics were used to analyze the pre-and post-test survey data following the implementation of the professional development training. The purpose of this analysis was to describe and illustrate how the training intervention impacted the consistency and quality of AT services in the transition program among a few participants in this preliminary study. Creswell and Creswell (2018) describe the use of means, standard deviations, and score ranges in the descriptive analysis of data. Survey responses contained ordinal scales that measured the impact of the AT training. For example, participants rated themselves from “1-never” to “4-always” on a quality indicator such as “AT use is written in the IEP in a way that describes how it contributes to the achievement of measurable outcomes or transitional goals.” This allowed the researcher to assess for statistical differences between the pre- and post-training responses. In addition to ordinal data, the open-ended survey questions provided the researcher with qualitative information about the participants’ perceptions, attitudes, and levels of confidence regarding the training content.

The researcher performed descriptive statistical analysis measuring changes in mean scores using the Qualtrics online survey instrument. Use of this instrument provided the researcher with numerical statistical data and visuals in the form of tables and charts to illustrate the impact of the professional development training on AT consideration and implementation among the three special educators. Data were analyzed on the following outcomes:

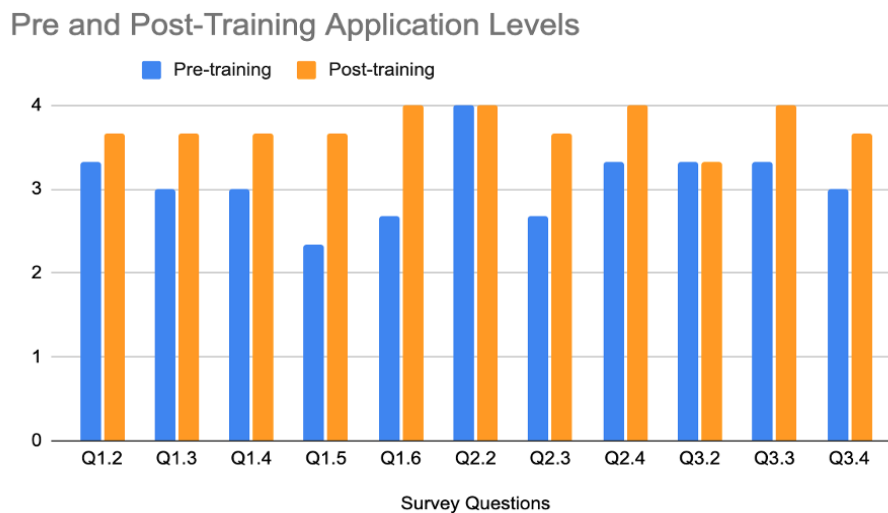
1. The changes in confidence among three special educators with knowledge and resources to match student need with AT tools.
2. The changes in three special educators’ abilities to thoroughly consider and assess individual student AT needs.
3. The changes in three special education teachers’ abilities to document AT consideration and assessment in special education comprehensive evaluations and individualized education programs (IEPs).
4. The changes in collaboration around AT problem solving between members of IEP teams, including transition students.

These outcomes aligned with the Quality Indicators for Assistive Technology (Bowser et al., 2015) AT service areas of consideration of AT needs, assessment of AT needs, and including AT in the IEP.

Results

The objectives of this preliminary study were to determine if program-specific AT professional development trainings increased special education teacher-reported application in the areas of AT consideration, AT evaluation, team AT collaboration, and AT documentation in IEPs. Additionally, it evaluated the changes in teacher confidence levels related to AT. Pre- and post-test surveys were used prior to and six months after two professional development one-hour trainings. The trainings occurred four weeks and seven weeks after the pre-test surveys. The Qualtrics online survey instrument was used to deliver the surveys and analyze data. Quantitative information was evaluated using descriptive statistics, while qualitative data were obtained through three open-ended questions to capture individual perspectives. Survey mean scores were compared between pre-training and six months post-training (Figure 1).

Figure 1: Application Ratings Pre- and Post-Training



Nearly all mean scores increased after the training intervention. The most notable increases in mean scores were associated with questions Q1.5 (“My IEP team has the collective knowledge, skills, and resources needed to make informed AT decisions and seeks assistance when needed,”) and Q1.6 (“Decisions regarding AT are based on transition goals and relate to information about the individual student, their environments, and tasks within those environments”). There was no change in the mean score of question Q3.2, (“AT consideration discussion results are documented in at least one section of the IEP”), suggesting the trainings did not change skills and application in this area of documentation with a mean score of 3.5 out of 4, indicating proficiency with this skill. Additionally, there was no a change in mean scores for Q2.2. However, this question elicited a rating of “4-always” before and after training for all three participants, indicating participants already viewed themselves as proficient in this area.

Mean scores for pre-training and six months post-training were visually examined. When pre- and post-test mean scores were visually analyzed by the section areas of AT consideration, AT evaluation, and AT documentation, a significant difference was noted in the area of AT consideration. Participants reported

overall increased frequency in the application of training content in the areas of evaluation and documentation. These results are summarized in Table 1.

Table 1: Comparison by Section (Pre-Training vs. Post-Training Intervention)

Survey Sections	Associated Questions	Pre-Mean (SD)	Post-Mean (SD)
<i>Assistive Technology Consideration</i>	Q1.2, Q1.3, Q1.4, Q1.5, Q1.6	2.87 (.34)	3.73 (.13)
<i>Assistive Technology Evaluation</i>	Q2.2, Q2.3, Q2.4	3.33 (.54)	3.89 (.16)
<i>Assistive Technology Documentation</i>	Q3.2, Q3.3, Q3.4	3.22 (.16)	3.67 (.27)

Limited information was gathered from the survey's open-ended questions, with 33.33% left unanswered among the group. Of interest, prior to the training, the words "somewhat" and "moderate" were used when describing knowledge and confidence levels, while one participant described themselves as "very confident" after training. One participant shared "I have gained knowledge this year and feel the AT evaluation process has been very streamlined with students in transition".

Discussion

This study addressed an AT service professional development need within a secondary transition program and provided information to enhance the existing program. This information can be used to guide future training interventions and program development to ensure that thorough well-documented AT consideration occurs for all students within this program to expand their work opportunities upon graduation.

This study focused on evaluating the impact of AT training for a group of special educators of secondary students with ID in transition as one method to address poor vocational outcomes among this population. The need to improve vocational outcomes for our community members with ID is well-established (United States Department of Labor Bureau of Labor Statistics, 2023; Winsor et al., 2022) and literature affirms that AT has great potential to improve task performance and leads to increased self-determination (Damianidou et al., 2019). The Quality Indicators for Assistive Technology (Bowser et al., 2015) were adapted to guide the pre- and post-test survey questions and overall content of this study's professional development trainings. The SETT Framework served as the project's guiding theoretical foundation and was used in the professional development sessions (Zabala, 2005). Training content included AT-related legislation and policy, district-specific AT guidelines, procedures, and supporting documents, as well as case studies to practice the AT consideration process using evidence-based low- to high-tech cognitive supports. This preliminary pre-experimental study found the application of the Quality Indicators AT service descriptors (Bowser et al., 2015) increased following program-specific training. The study was designed to meet four main objectives.

1. AT Service Confidence.

The first study objective was to improve the confidence of special educators with knowledge, skills, and resources to match student need with AT tools. This preliminary work investigated the change in this practice setting among three special educators after the AT training, an area not addressed in literature searches for comparison. The change in confidence was measured through open-ended questions on the pre- and post-training surveys. Response rate in this qualitative data section was low, with an 89% response rate on the pre-training survey and 33% on the post-training survey. Confidence levels were described as “somewhat” and “moderate” prior to training and the participant that responded to this question in the post-training survey described themselves as “very confident” after training. The poor response rate made it challenging to ascertain whether teachers felt more self-assured in their skills related to AT.

2. AT Consideration and Assessment.

The second study objective was to improve special educator abilities to thoroughly consider and assess individual student AT needs. Within the training sessions, the SETT Framework was used to guide the taught AT consideration process with specific examples of student characteristics, their program and work site environments, tasks within those settings, and a wide variety of tools to consider when making decisions regarding accommodations to increase independence and meaningful engagement. The AT quality indicator area of *consideration of AT needs* was determined to be changed by the trainings suggesting that additional training in the SETT decision-guiding structure positively influenced AT consideration specific to the needs of young adults with ID exploring work opportunities. This reinforces the use of Zabala’s SETT Framework (2005), in its ability to promote collaborative decision-making, supporting both participation and success honoring the individual strengths and needs of each student.

3. AT Documentation.

The third objective was to improve special education teachers’ abilities to document AT consideration and assessment in special education comprehensive evaluations and IEPs. Reported levels of application of content either stayed the same or increased slightly in this area and were not determined to be large. This is an area that warrants further investigation into the effectiveness of training design and content.

4. AT Collaboration.

Finally, this work aimed to improve collaboration around AT problem-solving among members of IEP teams, including transition students. The special educators involved in this study reported increased frequency in the inclusion of transition program students in AT consideration discussions. As active problem-solving members of their educational plans and necessary adaptations, these young adults will gain opportunities to develop independent decision-making. The importance of self-determination became a theme in reviewed studies. Duvdevany et al. (2002), Foley et al. (2012), and Wehmeyer and Palmer (2003), all discuss how critical self-determination skills are during this transition. It is linked to positive outcomes in all areas of life, including employment. Student involvement in these AT discussions and problem-solving is vital to develop these skills, leading to increased ability to self-advocate for needed technology in future work settings.

Limitations

This preliminary study was not without limitations. The biggest limitation was a small sample size. Only three special educators participated in this study. In addition, the duration of six months’ time between the pre- and

post-test was designed to provide adequate time for the special educators to implement what they learned in the training sessions as they completed transition program student evaluations and individualized education programs. However, this could be viewed as a threat to internal validity, as confounding variables may have influenced participants outside of the training intervention. These confounds may include other AT education, changes in student caseload, and changes in learning due to COVID-19. The poor post-test response rate for open-ended questions was unexpected and can also be viewed as a study limitation. One reason for this may be the timing of the post-survey distribution. The survey was distributed by email the first week the special educators returned to work at the start of a new school year. This transition is often a stressful time for teachers, with added anxiety due to unknown factors related to the COVID-19 pandemic and learning models associated with mitigation strategies. This stress may have impacted these participants' ability to devote their detailed attention to the survey, skipping over some of the questions. Scale ratings alone do not capture meaningful information such as individual conceptualizations, feelings, and beliefs, as qualitative measures could have. These aspects are perceived by the researcher to be important areas to consider when determining the impact of professional development opportunities. Additionally, despite careful consideration in the development of survey questions to reduce response bias, when using a digitally delivered survey, participants may have different interpretations of questions when they are not presented in a face-to-face format. Future research should aim to use validated instruments for data collection. Lastly, the researcher's district role as assistive technology specialist may have influenced responses to questions. Although surveys were anonymous, it is possible the participants may have overinflated pre-training scores due to social desirability bias.

Outcomes and Benefits

This work, even though limited in scope, provides valuable outcomes to guide decisions on efforts to build capacity in AT services in transition programming for young adults with ID. Capacity building allows special education teachers to strengthen their skills in current AT trends and innovations while applying best practice as outlined in the Quality Indicators document (Bowser et al., 2015). It is hoped that thorough AT consideration and implementation in this pre-vocational setting, young adults with ID will experience better, lasting, and fulfilling employment outcomes, thereby positively impacting their overall health and well-being.

As a pre-experimental designed feasibility study, this work provides benefit by providing initial results of an educational program focusing on best practice AT using the Quality Indicators (Bowser et al., 2015). These favorable initial outcomes establish the need for continued research in this transition setting, expanding it to a larger population of special educators in multiple programs. With a strong focus on improving vocational outcomes, a future application would be to assess long-term relationships between quality AT services based on the Quality Indicators (Bowser et al., 2015) and levels of work opportunities and job satisfaction among young adults with ID. This is important in the evaluation of programming intended to develop self-determination skills and participation in meaningful work occupations that provide life satisfaction and occupational balance.

The design of this study benefits the AT community by illustrating one way to utilize the Quality Indicators matrices (Bowser et al., 2015) to evaluate and monitor the application of quality AT services. This basic design can be replicated and expanded on to include the other important areas of AT service delivery not addressed in this study, including AT implementation, evaluation of the effectiveness of AT, AT in transition, administrative support of AT, and professional development and training in AT (Bowser et al., 2015).

This study demonstrated that there was an increase in AT consideration after the training modules were implemented. This positive finding suggests that AT practitioners could benefit from learning about the Quality Indicators for Assistive Technology (Bowser et al., 2015) in their practice. Such a resource would allow for greater clarity and implementation of best practice in AT.

This study and its results also benefit the AT community by reinforcing the use of the SETT Framework (Zabala, 2005) as a model for providing services, thus demonstrating AT practitioners' ability to promote collaborative decision-making and professional competence in matching individual students with AT tools specific to their environment and tasks.

Declarations

This content is solely the responsibility of the author(s) and does not necessarily represent the official views of ATIA. No financial disclosures and no non-financial disclosures were reported by the author of this paper.

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Appendix A

Pre- and Post-Training Survey Questions

AT Consideration

How knowledgeable and confident do you feel in the IEP AT consideration process?

Assistive technology devices and services are considered for all of my students, regardless of the type or severity of the disability (for example, I consider AT for students with memory and attention needs in addition to physical needs).

1. Never
2. Sometimes
3. Most of the Time
4. Always

Transition program students are involved in an AT discussion at their IEP meeting.

1. Never
2. Sometimes
3. Most of the Time
4. Always

During IEP development, a collaborative decision-making process is used that supports a systematic consideration of each of my student's possible need for AT devices and services.

1. Never
2. Sometimes
3. Most of the Time
4. Always

My IEP team has the collective knowledge, skills, and resources needed to make informed AT decisions and seeks assistance when needed.

1. Never
2. Sometimes
3. Most of the Time
4. Always

Decisions regarding AT are based on transition goals and relate to information about the individual student, their environments, and tasks within those environments.

1. Never
2. Sometimes
3. Most of the Time
4. Always

AT Assessment

How knowledgeable and confident do you feel in the AT Evaluation process?

The district "Assistive Technology Checklist: Transition" is included in every student's special education evaluation, at a minimum.

1. Never
2. Sometimes
3. Most of the Time
4. Always

Use of the district "Assistive Technology Checklist: Transition" is a collaborative process, completed with more than one team member.

1. Never
2. Sometimes
3. Most of the Time
4. Always

When my student's IEP team does not feel they have the collective knowledge, skills, and resources to fully evaluate AT for more complex student needs, I seek assistance from an AT or AAC Specialist.

1. Never
2. Sometimes
3. Most of the Time
4. Always

AT Documentation

How knowledgeable and confident do you feel in the AT documentation process in comprehensive evaluations and IEPs?

AT consideration discussion results are documented in at least one section of the IEP.

1. Never
2. Sometimes
3. Most of the Time
4. Always

When AT is identified as a need through the consideration process, AT services are included in the IEP services grid.

1. Never
2. Sometimes
3. Most of the Time
4. Always

In the IEP, AT is described in a way that clearly relates to student needs and transition goals and objectives.

1. Never
2. Sometimes
3. Most of the Time
4. Always

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Voices from Industry

Accessible Mobile Phones: Bridging the Gap in AT Provision and Service Delivery

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Abstract

The history of accessible digital and mobile technologies, from mobile phones and tablets to smartwatches and wearables, offers a case study in how such devices have made a significant difference in the lives of people with disabilities and older users. A review of more than 20 years of mobile phone development also demonstrates how the three-pronged approach of policy initiatives, industry efforts, and end-user advocacy resulted in a wide range of accessibility features. These features not only facilitate the use of the device and access to digital content, but more and more, include assistive functions that improve access to the environment as well. In the absence of a comprehensive chronicle of mobile accessibility, we refer to the GARI database, founded in 2008 and since then reporting on accessibility features of mobile phones to facilitate consumer choice. GARI serves as a proxy to analyse how far we have come in making consumer electronics accessible. With this information we can look back and take account of where we are in 2023 and explore how accessible and assistive technologies are becoming closely integrated within the mobile device. The lessons learned, and this lengthy experience provides a framework for the future development of innovative and disruptive technologies to ensure that the progress made is taken forward into a new generation of technologies.

Keywords: accessibility, assistive technology, mobile phones, consumer electronics, wearables, GARI, people with disabilities, older users, wireless technology

Personal Statements

David Banes

Director of David Banes Access and Inclusion Services and a director of DATEurope, the Digital Assistive Technology Association for Europe. He was formerly CEO at the Qatar Assistive Technology and Accessibility Center. David has developed services ensuring the digital inclusion of disabled people. He works globally to address how access is maintained and advanced during periods of change, seeking to build capacity, linking awareness, policy, technology development, and the need for training. With a background in special needs education and supporting digital inclusion in Europe, he promotes emerging access ecosystems, facilitating stakeholder cooperation to develop accessible technology solutions and content.

Recent work includes a framework for contextualization of access technology, transference of knowledge across communities, and a policy framework to address the rights of people with a disability. His current activity includes digital transformation of public services, shaping an identity for Digital AT, and the potential impact of AI on assistive design as disruptive innovation in the access industry.

Sabine Lobnig

Sabine is the MWF's Director for Communications and focuses on advancing the Global Accessibility Reporting Initiative (GARI). GARI's mission is to inform consumers about existing accessibility solutions in the market today.

Sabine has extensive experience supporting international organizations and companies in digital inclusion. She has actively supported the expansion and progress of the GARI online database for accessible devices in 20 languages and regularly coordinated stakeholder reviews of the GARI project (gari.info). She supports AAATE in several EU projects and is a founding member of the D-A-CH Chapter of the International Association of Accessibility Professionals (IAAP).

Michael Milligan

Michael is the MWF's Secretary General. He established the GARI project and has since overseen its development and expansion. Having seen the enabling power of mobile technology to assist in the classroom, he has a personal interest in promoting GARI as widely as possible to ensure that those with particular needs can find a device that best meets them.

Target Audience and Relevance

This article is aimed at policymakers, assistive technology professionals, and the developers and designers of emerging technologies for the use of people with a disability. For each group, we highlight the journey made to achieve the current scale of accessible mobile phones and suggest some of the key issues to consider in applying this experience to future developments. Lessons learned need to be applied to the definitions of accessible technologies and the provision models, the process of matching people to appropriate solutions and the design of devices and solutions in the immediate future.

Accessible Mobile Phones: Bridging the Gap in AT Provision and Service Delivery

The Early Years of Mobile Technologies

Mobile technology has played a vital role in increasing access to digital information and content for people with a disability for more than 20 years. In understanding the journey and identifying lessons learned throughout that period, we can look ahead and begin to consider how both mobile phones and further innovation, as well as related emerging technologies, can impact people with a disability. The potential scale of impact is reflected in the numbers. In 2021 there were 5.3 billion mobile phone active subscriptions (~67% of the global population; GSMA, 2022); 1.3 billion people who experience a significant disability (~16% of the global population worldwide). To consider the potential of this level of use we can note that today an estimated 2.5 billion people require assistive products (WHO, 2022).

These numbers, when combined with the knowledge that mobile technologies have become the hub and main channel for accessing the internet and participation in our modern societies, when much of our public, professional, and social life happens online, indicate that these technologies can become central to bridging the gap in the delivery of assistive products and services.

Although the earliest mobile phone, developed by Motorola, was demonstrated in 1973 (Wikipedia contributors, 2023 August 16), it took a further decade for the first mobile phones to be introduced as potential consumer technology. The early phones bore little resemblance to modern handsets and were hefty and expensive. Many perceived them to be a status symbol for the wealthy as they became featured in Hollywood movies such as *Wall St.* and *Lethal Weapon*. With limited additional functionality and battery life, it was not surprising that those with disabilities did not embrace such phones for a number of years.

The modern mobile phone era can be traced to 1987 and the advent of GSM (Wikipedia contributors, 2023 August 16). This common standard derived its name from “Groupe Spécial Mobile”, but it rapidly changed to become the “Global System for Mobile Communications.” While earlier phones had been based upon analogue signals, the GSM system was digital, known as a “second generation” or 2G system. The advent of common frequencies used throughout Europe and much of the world enabled far wider usage, and by 1992, models began to include features such as short message service or SMS, now often referred to as texting.

Mobile phones became popular from the 1990s and increasingly pervasive since the arrival of the smartphone in the late 2010s. Device manufacturers have integrated features to help people with disabilities and older users with the use of the device, as well as to get access to the content provided via those devices. This was partially encouraged by legislation such as Section 508 of the Rehabilitation Act (1998) and the 21st Century Communications and Video Accessibility Act (CVAA, 2010) in the US, and partially by engagement with the disability community who provided manufacturers with concrete feedback on what kind of accessibility features were needed. In 2008, the Mobile & Wireless Forum (MWF, at the time called Mobile Manufacturers Forum, MMF) and accessibility experts created the first list of accessibility features that manufacturers would report on, in order to help consumers with disabilities find mobile phones that would work for them. However, mobile technology has a longer history than this.

By the mid-1990s, various handsets were emerging on the market. Flip phones offered automatic answering of calls as the cover was released from the keyboard, and different models had a range of screen sizes, keyboards, and capacity to be enhanced with peripherals, such as a plug-in headset or microphone. As designs began to diversify, consumers could make individual choices according to their preferences and ease of use. The appetite for easy-to-use handheld devices with different settings was to evolve into the modern concept of accessible handsets, drawing upon a much longer established history of accessibility options built into personal computers.

The advent of SMS (Wikipedia contributors 2023, July 9) offered a unique means of communication for those who were deaf. This mainstream feature was one of the first features offered to all owners, bringing extensive additional benefits to those with a disability. It has been suggested, although never confirmed, that Matti Makkonen first discussed the idea of SMS in Copenhagen in 1984 (Wikipedia contributors 2023, February 7). Whilst Makkonen may have envisaged SMS for those who were deaf to assist in communication, it was the opportunity for SMS to offer a means to save bandwidth that cellular telecommunications changed. For those who were deaf or hard of hearing, the huge impact of SMS lay in the fact that it was a mainstream technology rather than a specialized assistive technology that had been designed specifically for deaf people or people with disabilities. Such assistive products were often expensive and hard to find. As early as 2001, the press was reporting how this medium was replacing pagers and minicoms to stay connected for deaf people and, moreover, that the success of the medium was influencing the development of features that would build upon 3rd generation connectivity (3G; Wikipedia contributors 2023, August 23), not only for those who were deaf but also for the much wider population.

The Rise of Feature Phones 2000-2009

At the turn of the century, the use of mobile phones had grown dramatically. Nokia introduced the world's first mass-produced 2G phone in 1992 (Borhanuddin & Iqbal, 2016), a mobile phone with a full keyboard in 1996, and the first handset to be available in a range of colours in 1998 to coincide with London Fashion Week. Alongside the first “vibrating” phone, the StarTac, developed by Motorola in 1996 (Wikipedia contributors 2023, August 12), there was a diversity of choices for many people, including those with disabilities. But until this point, the use of such phones by those with disabilities was driven by hardware design, such as haptics or keyboards and the application of mainstream features to address individual needs. With the advent of 3G connectivity that was fast enough for internet use, new options emerged, many of these built upon the Symbian OS developed by Nokia.

Symbian was to dominate much of the market for the next decade and saw the evolution of new features that set a new bar for access and a legacy upon which early smartphones were to build. Its first availability in 2001 included multi-language support, Bluetooth connectivity to other devices, cut, copy, and paste support, alerts, audio and video playback, GPS, and the ability to add third-party software from an app store. By 2006, two further key features were included: the underlining of text to represent spelling and grammar errors, and early applications that enabled voice recognition.

Simultaneously, the ease of use of mobile handsets to produce text drove the development of word prediction and completion. The T9 text prediction application was merged into Symbian OS in 1998 (Techmonitor, 1998) and offered a “smart input” technology based on the use of a keypad. Each key contained multiple letters, and the user pressed a key only once to access the letter they needed. The T9 algorithm automatically selected the word that was most likely being typed from a database of more than 60,000 words. Mobile phones

increasingly became the preferred means to communicate by voice and text. Keyboards and word prediction offered realistic options for those with physical needs, hearing loss, or who faced issues with processing text, such as people with dyslexia. Nokia had gone as far as to introduce an induction loop for the hard of hearing that linked their phones to digital hearing aids in 1998 (Global Newswire, 2000). Within 10 years, this had evolved into a Bluetooth loop for personal use that would work with any handset that supported Bluetooth technology.

However, it was not for several years that technology became widespread to make Symbian OS more accessible for those with vision loss. But by 2006, Talks and Zooms from Nuance and Mobile Speak by Code Factory could be purchased and installed onto a range of Symbian devices (Burton, 2007), most notably those produced by Nokia. Talks and Mobile Speak offered the full functionality of a screen reader for Symbian devices, Zoom, a magnification package that was bundled with Talks by Nuance as part of an accessibility suite where products could be purchased separately or together. While people with little or no vision had used mobile technology to speak to friends and colleagues for several years, the advent of these packages made the additional features and functions fully usable for the first time. Texting, email, and web browsing were now possible for an even greater number of users. Increasingly, these functions built on mobile technology were embraced by the disability community alongside their non-disabled peers. This created the expectation that mobile technology could and should be designed for universal access. One of the last Nokia Symbian phones, the N95, integrated many of these features into one device, even emulating a games console, and can be seen as the bridge between phones that offered much more functionality and handheld computers that also made phone calls as epitomized by the smartphone.

The Advent of Smartphones – Driven by Touch Access

The concept of smartphones has a longer history than many might assume. The IBM Simon was the first of its kind when it came out in 1992 (Wikipedia contributors 2023, August 9). The Simon included a touchscreen, was portable, had a calculator and email, and could work on networks. It was the first time someone created a mobile computer in the shape of a phone. It was far ahead of its time, while other devices were introduced as personal digital assistants such as the HP iPaq or as media players such as the Microsoft Zune or Apple iPod. However, it is possible to trace the advent of the modern smartphone to 2007 and the launch of the Apple iPhone.

A smartphone is a portable computer device combining mobile telephone and computing functions into one unit. They are distinguished from “feature phones” by their more advanced hardware capabilities and extensive mobile operating systems, which facilitate a broader range of software, access to the internet (including web browsing over mobile broadband), and multimedia functionality (including music, video, cameras, and gaming), alongside core phone functions such as voice calls and text messaging. Smartphones typically contain several sensors that can be leveraged by pre-installed and third-party software (such as a magnetometer, a proximity sensor, a barometer, a gyroscope, an accelerometer, and more), and support wireless communication protocols (such as Bluetooth, Wi-Fi, or satellite navigation). More recently, smartphone manufacturers have begun integrating satellite messaging connectivity and satellite emergency services into devices for use in remote regions with no reliable cellular network.

A critical innovation in the growth and use of smartphones was the inclusion of touchscreen access. Earlier innovations in touch access had replaced the use of a mouse with a stylus. This had stimulated use of personal digital assistants such as the iPaq, but greater ease of use became a core selling point with the

availability of a truly intuitive interface, with multitouch, gestures and “apps,” that was integral to the early iPod touch, iPhones, and iPads. As the devices became capable of being used by anyone at any time, further access requirements were requested and implemented. These were to include text-to-speech, dictation, and digital assistants.

Since the launch of the iPhone based upon the iOS operating system, several other systems have been released onto the market. These include Windows Phone, KaiOS, other proprietary operating systems, and later, the open-sourced Android. While some have achieved a degree of traction as a low-cost option for low and medium-income markets in most regions, sales of smartphones have been dominated by Apple and their iOS operating system and a range of manufacturers building on the Android operating system. By 2009, these two operating systems were the basis of the vast majority of smartphone sales, with feature phones such as those based on Symbian declining despite continued use in low-income and low-resourced environments. With the launch of the iPhone 3Gs and Android “Donut” in 2009, the first steps were taken to accelerate the accessibility of smartphones. Both operating systems incorporated a screen reader, options for magnification, word prediction, and the capacity to connect to a range of peripheral devices via Bluetooth, including hardware keyboards and pointing devices.

As the range of accessibility features and third-party enhancements expanded and evolved, it became essential to make additional efforts to assist people with disabilities to understand the available options. While some countries had national requirements for information provision for those with disabilities, it was not until the creation of the Global Accessibility Reporting Initiative (GARI) in 2008 by the Mobile & Wireless Forum (MWF) that one comprehensive and global information source on the available accessibility features within mobile phones was established.

Figure 1: Stakeholder Engagement in Gari



The Expansion and Growth of Accessibility Features and Smartphones

The rapid growth of access solutions for mobile technologies is reflected in how GARI has developed into an extensive database where information is collected, stored, and curated to raise the profile of the accessibility features in more than 1,500 devices, including mobile phones, tablets, smart TVs, and wearables. It also includes information on accessibility apps that work on these devices. The database is freely accessible online, available in 20+ languages, and used by governments, user organisations, telecom providers, and

many other stakeholders worldwide. The range of features added to the database provides a clear summary of the expansion of concepts and tools to enhance the accessibility of the devices.

In 2013, the GARI feature review identified a series of key functions that had been added to operating systems. These included additional support for people with hearing loss through greater hearing aid compatibility settings, while other innovations for a diverse range of needs included further support for refreshable braille displays, visible focus indicators, support for gesture-based navigation, and recognition of those with high-impact physical impairments with support for an external switch and pointer support, making access feasible for those who are deaf/blind. For the first time, those with a physical disability were able to transfer the technology they used with a computer to control a mobile device, heralding a much greater opportunity for universal controls for technology.

The GARI feature review in 2015 did not identify any significant additional features for inclusion in the database, but by 2017, the increased uptake of devices by people with a disability had led to a need for many further features to be included. At this stage, the database added features that supported a greater diversity of users and provided further depth to the features already available. For those who were deaf or hard of hearing, the addition of real-time-text capability and textphone/TTY compatibility, alongside haptic feedback for alerts and notifications, provided greater opportunities for communication. Equally, with the expansion of 4G networks, sign language communication became possible with improved compression of video data, making high-quality video calls a possibility on mobile networks. At the same time, improved dictation tools supported those with cognitive needs—including reading impairments—who also welcomed the addition of integrated personal assistants with greater voice control, not only of text but also for the functions of the device. The use of phones by people with limited dexterity had also grown with the improved voice control, and this was further facilitated by greater external keyboard support, enhanced external switch and pointing device support, and with options for device coupling using cables.

The feature review of 2019 demonstrated how the range of accessibility features was increasing and evolving as greater feedback was provided and expectations of access increased. At this stage, additional features included the use of biometric logins that reduced the frustration felt by many older users with memory loss. Further support for third-party physical keyboards, including those connected by Bluetooth, made typing easier, whilst options to choose between light and dark themes helped to increase readability and ease of use. Further support for the deaf and hard of hearing came with added support for a wider range of induction loops and volume control options. This period also saw the first introduction of intelligent personal assistants with early technologies beginning to analyse, predict, and anticipate needs to support the user.

The pace of innovation and the growth of features to support those with different needs has continued to accelerate, with a growing expectation that no one should be excluded from the use of technology as a result of poor design. The most recent review conducted by GARI in 2022 added a range of further features that included technology for those with hearing loss, such as audio streaming to hearing aids, automated transcriptions, and adjustable captions for audio and video, contributing to total conversation capability and the recognition of atypical speech patterns. Innovations brought new ways of interacting with technology that addressed some of the barriers created by other forms of control. Control systems such as air gestures, facial gestures, and eye tracking, where physical contact with the device is not necessary, as well as assistive touch and focus modes, continued a legacy of innovation for access that benefitted not only those with disabilities

but also many people who did not self-identify as disabled, but who had experienced frustrations with earlier iterations of technologies that had not considered them as potential users.

Accessible Digital Content

A further driver in the uptake of mobile technology has been the growth of online accessible content. The State of Accessibility Report (Aquino, 2021) explored accessibility trends and the top 100 most visited websites across several years, providing a valuable snapshot of the extent of web accessibility each year. Their findings are interesting, especially as they cover the period of the COVID-19 pandemic. In 2019, 21% of the 100 most visited websites were accessible, 24% were accessible with difficulty, and 55% were inaccessible; by 2021, 62% were accessible, 9% were accessible with difficulty, and 29% were inaccessible. It is likely that many less popular websites are less accessible than the top 100, and this is reflected in the WebAim finding that only 3% of web content is accessible (WebAim, 2023). But, in terms of value and traffic to those websites, we saw digital content offered by social media companies, e-commerce, and broadcasters increasingly being accessible to people with a disability when combined with an application on their phone or tablet. The availability of desirable and accessible content increased the usage of accessible devices by people with disabilities, recognizing the adage that “content is king.”

“There’s an App for That” – How Apps Enhanced the Use of Consumer Technology for People with a Disability

Since 2009 and the rapid growth of smartphone usage, there has been a corresponding growth in the proliferation of apps for both iOS and Android to meet the needs of people with a disability. The growth of such apps should not be seen as something that is divorced from the evolution of the access features integrated into those phones. The relationship is important. Most apps use the accessibility features of phones as core building blocks upon which a new application or use can be built. For instance, the combination of touchscreen and text-to-speech in early IOS models led directly to an explosion of Alternative and Augmentative Communication (AAC) applications for those without speech or who needed additional support to express themselves in conjunction with speech. The availability of such apps had a major impact on the market, acting as a disruptive innovation and, in many cases, replacing dedicated devices with software based on a consumer device.

Similarly, handheld magnifiers were increasingly replaced by magnification applications for phones and tablets as the camera resolution improved and sharp focus became the norm. The quality of the lens, sensor, and processor meant that many of the features of dedicated devices, such as magnification, image stabilization, contrast, and color switching, could now be replicated on a mobile device for a fraction of the cost. This was further driven by the desire of many people with a disability to carry fewer devices and instead to use one device to provide multiple functions.

As these innovations became popular and digital inclusion became smartphone-centric, software developers for PCs began to take the opportunity to transfer some of their products to the new platform. Companies such as Claro, Dolphin, TextHelp, Sensory App House, and Nuance released apps that offered some of the features of their PC software on mobile devices; increasingly, they allowed files and content to be shared and accessed across both PC and mobile devices for a seamless experience. These trends were not ones that were solely observed in the realm of assistive technology. Similarly, shifts occurred in multiple fields as websites such as Facebook offered apps for mobile use, and companies such as Adobe offered versions of their photo editing suites for phones and tablets.

As new features and functions are introduced to mobile devices, we see new assistive applications emerging. Geolocation allowed the development of mobile apps for navigation, orientation, and wayfinding; enhanced connectivity facilitated accessible smart home apps controlled by speech, and AI began to offer new ways to caption video, edit and understand text, generate images with alt text, answer questions with answers scraped from multiple sources, and create well-formed text for email and writing.

This explosion of apps would not have been possible without the accessible platforms, devices, and OS to build upon, and the range of applications continues to expand. But as we look forward, we must appreciate what has been built into the devices to ensure that future platforms offer the same or greater building blocks for next-generation technologies.

Discussion

The Impact of Mobile Technologies

The history and evolution of mobile phones and tablets as accessible and enabling technology is extensive and reflects a process undergone over many years. As a result of this, increasingly, there is a dependency upon these devices as a means of access for people with a disability globally. The impact of mobile consumer technology has been significant.

In a report prepared for the MWF, Banes (2019) noted that mobile technology has become a critical, core aspect of the ICT and telecommunications industry. By 2017, over 5 billion people globally were connected to mobile services (GSMA, 2017). This continues to grow, driven by low- and medium-income countries, including India, China, Pakistan, Indonesia, and Bangladesh. While the market in the West has become saturated, significant social groups remain underrepresented, including the elderly and those with a disability. In a report prepared by GSMA in 2018, mobile internet adoption was predicted to become the key metric to measure the reach and value created by the mobile industry, including its contribution to the UN's Sustainable Development Goals (SDGs; GSMA 2018, 2022). Furthermore, the GSMA report suggests that while growth would begin to slow, the number of unique mobile subscribers will reach 5.9 billion by 2025, equivalent to 71% of the world's population. Growth beyond this figure is likely to require greater attention to those who are hardest to reach, including those with disabilities.

There is a long legacy of products designed to make disabilities easier to live with, but assistive technology seems more pervasive and in demand than ever. Morrissey (2019) observes that as people with disabilities have access to smartphones and computers, which are increasingly affordable, they have the means to make themselves visible in a way they never could before.

However, emerging and innovative technologies offer still greater opportunities to provide assistive features and functions through consumer devices, for instance, the advent of 5G. This has impacted the design of assistive technologies, allowing them to move into the cloud and offer more pervasive and always-connected solutions. Connectivity facilitates technology availability regardless of location; we see this in action through devices such as phones, tablets, and wearables. As a result, people with a disability increasingly expect their technology to be available on demand.

Equally, Artificial Intelligence (AI) is driving the design of assistive technologies through data analysis, offering a predictive and personalized experience with increased automation of functions. AI is fully integrated in today's smartphones, supporting the user in taking better photos and editing them with different filters, identifying favourite music, translating between languages, and having a better gaming experience. The device learns with the user and adapts to individual speech patterns for better voice recognition and dictation (Qualcomm, 2023).

Generative AI such as GhatGPT offers new techniques to produce written materials that can then be personalized and customized to a specific audience. Many people with disabilities are beginning to use such tools to help create the structure for writing and to build prompts and suggestions for content. Similarly, early efforts are being made to use generative AI to maximize accessibility through auto-production of alternative text for images and even the creation of new symbols to support cultural preferences of AAC users. While not without some concerns regarding data privacy and security, AI has the potential to further assist those with disabilities in many ways—including predicting and anticipating communication needs, such as vocabulary and responsivity.

The impact of mobile devices increases constantly due to new features and capabilities of the mobile devices themselves. From aids for essential functions such as bathing or feeding to more complex digital tools such as environmental control systems or smart homes, these devices support those with disabilities to interact with the physical world through remote controls for doors, lighting, temperature, and other aspects of the built environment. Such control stimulates and ensures greater autonomy.

Ensuring personal mobility requires not only mobility aids such as walking aids or prosthetics, but also support through technologies for wayfinding and orientation that provide information about the built environment to guide users and help in decision-making when planning trips. Such technologies are often built upon consumer devices. Many public transport companies, for instance, use mobile apps to convey information about their services in an accessible way, adding value to all consumers, but, most importantly, guiding those facing barriers to travel or refraining from using public transport due to the challenges of planning ahead.

The emerging assistive products that facilitate this expansion have been developed, assuming that a smartphone or similar device will be available to users. The function and application of the technologies are subject to ongoing evolution and disruptive design. Some of the specific technologies that are influencing development include:

- **Speech and natural interfaces.** Speech interfaces are used as input or output based on automatic speech recognition (ASR) and natural language processing (NLP). Technology such as Amazon Echo or Google Home, and those with built-in functionality such as Apple's Siri, Google Assistant, or Amazon's Alexa, offer options to make an environment accessible.
- **Internet of Things (IoT).** IoT is reshaping society by changing the daily life of users. Assisted living, smart homes, and smart health are all scenarios in which this will play a role for people with disabilities (Atzori et al., 2010). IoT enhances assistive technology by adding capabilities that support independence in communication, self-care, independent living, health care, mobility and transportation, and education and learning (Lee, 2017).
- **Artificial Intelligence.** Artificial intelligence (AI) leads to innovation in many fields for people with disabilities. With developments in predictive text, visual recognition, and speech-to-text transcription, AI now stimulates other products and features that expand opportunities for those with disabilities.

The Seeing AI app verbally describes people, text, and objects for those with no or low vision. Livox is an AAC app that allows people without speech to communicate using symbols that respond to context easily.

- **Augmented Reality (AR).** AR increasingly impacts rehabilitation by using virtual objects and overlays to enhance interaction with exercises and activities. It makes training more understandable and can help users understand their available devices and technologies. Virtual Reality may integrate treatment and entertainment through virtual and gamified environments. This can increase motivation and commitment to rehabilitation and other activities that a person might find challenging.
- **Wearable Technology.** Wearable technology delivers assistive and accessible features in a variety of ways. They can act as sensors to gather data through smartwatches or fitness trackers and provide information in a non-obtrusive manner. They have a long history and include hearing aids and Bluetooth headsets, while smartwatches have grown in popularity and functionality in recent years. As such devices become more prevalent, forms of assistive technology use the platforms to control other devices and give alerts and notifications, improving personal health and safety.

Emerging technologies are moving from providing specialist devices designed solely for those with a specific need to an increasing blend with mainstream technology that benefits all users. This reflects the increased implementation of universal design principles and the technology's pervasive nature, which often demands access in challenging settings.

In addition, mainstream technologies increasingly embrace the redundancy of inputs, integrating gesture, sound, and vision, giving users greater flexibility to determine how they wish to engage with information and establish control. This blurs the boundaries between assistive and mainstream technologies further.

As consumer devices become increasingly accessible, more users with disabilities are identifying accessible consumer electronics as an effective way to address their needs. The devices provide a range of accessible and assistive functions rather than only addressing one specific function. For many people with a disability, there is greater enjoyment in using mainstream products that avoid the stigma of using dedicated devices.

The greater value of accessible mobile devices that provide integrated text-to-speech, voice recognition, word prediction, and screen-readers alongside other accessibility features lies in being the core for comprehensive and personalized solutions upon which an ecosystem of features and functions can be built. Such an ecosystem might include fall detection, AAC (alternative and augmented communication), sound amplification, and wayfinding, based upon an increasing trend among users to have single devices which are able to perform multiple functions. The device upon which they read a book is the same device they use to navigate a city. At the heart of user preferences is a multi-tiered approach which offers accessible digital content through an accessible device, upon which further features and functions can be added and integrated. By offering a diversity of different uses, they also offer additional value as the preferred platform of users with disabilities, which is likely to reduce abandonment and reach into the widest parts of their lives, including social, leisure, and entertainment functions. The experience of the COVID-19 pandemic suggests that such devices and functions are central to users' emotional well-being as an effective means of responding to social isolation and exclusion (David & Roberts 2021); while social distancing was the most effective means of protecting physical health during the pandemic, social and emotional health was dependent on communications technology. Similarly, McClain et al (2021) report how technology allowed people to maintain

relationships alongside access to employment and education through the increased use of video calls, online gaming, and social media.

Unanticipated benefits and the impact that the joy of using these technologies can have on people's lives require further investigation. Research studies currently being undertaken at University College Cork (Boyle 2023) have begun to consider how people with disabilities derive pleasure from the technology they are using and seek to understand what this would mean for well-being and quality of life.

Ultimately, there is increasing evidence that these devices empower people with disabilities to live independently, gain employment, succeed in education, and facilitate broader participation in social and political life. To continue reinforcing barriers to provision through outdated distinctions would be effectively denying access to available products and will only maintain the global failure to meet demand.

However, the trends described above suggest that we are on the cusp of a new generation of smart devices that will bring still further opportunities for those with disabilities. Wearables, smart homes, augmented and virtual reality, and smart speakers are just some of the technologies that are being rapidly deployed in the home, for learning, and in the workplace, that might enhance the experience of people with disabilities.

To achieve this and not retreat from the progress of the last 40 years, it is important to consider the lessons that have been learned from the past. In reviewing the progress, some of the key lessons that we can consider are:

1. Consumer technologies matter and need to be recognized as central to inclusion. Such recognition needs to be driven by the disabled community and reflected in both policy and practice in the provision of technology for people with a disability.
2. Consumer hardware provides the platform for low-cost and accessible products upon which access can be built.
3. The breadth and depth of access features on phones and tablets must be replicated and enhanced in the operating systems for next-generation technologies.
4. A healthy commercial and open-source ecosystem of third-party enhancements, apps and peripherals is essential to meet the diversity of users' needs. Enhancements such as AAC apps or orientation tools are essential in addressing the depth of individual needs and high-impact, low-incidence disabilities.
5. Any ecosystem must seek to create more fertile territory for implementation, building capacity within which technology can be introduced successfully. This will include awareness, matching people to technology, provision models, training, technical support, and availability of accessible content. Such an ecosystem grows through research and development and is woven together by policy.

The engagement of people with a disability in the design process as co-design partners helps ensure that innovation is inclusive and that the historical experience to date is a foundation for emerging technologies.

Much has been achieved. By charting some of that through the GARI database, we see that inclusion through technology was achieved through both incremental and disruptive innovations. By bringing both strategies to bear on development, we take the opportunity to build on what has been achieved.

Outcomes and Benefits

Today's smartphones include accessibility features that can complement—and in many cases, replace—specialized assistive technology (AT) such as screen-readers, screen loops, speech-to-text programs, or alternative augmented communication (AAC). In some cases, an accessible mainstream device would even better fulfil the requirements of users with disabilities and individual access needs than a specialized AT. Many students, for example, would prefer an accessible smartphone, tablet, or computer for following classes and lectures, as they are mainstream devices and are often available at more affordable prices than usual AT. However, mainstream devices are rarely eligible for funding, which is usually limited to specific selected equipment.

The analysis of the key features that support accessibility for smartphones and tablets showed that they focus on making the device more usable for people with disabilities and, from this aspect, do not directly fall under the definition of assistive technology used to drive provision. While they may share a common broad definition, the identity of traditional and digital products is shaped by a separate ecosystem with very different forms of development, distribution, and implementation. A rapid review of national criteria for provision of assistive products undertaken by the authors revealed little or no explicit reference to consumer technologies, and some suggestions that these were excluded.

However, a comparison with international standards (including the WHO's Priority Assistive Products Lists, the ISO 9999 standard on "Assistive products for persons with disability," the EN 301 549 on "Accessibility requirements for ICT products and services," as well as the Section 508 requirements for accessible ICT in the US and the International Classification of Functioning, Disability, and Health) revealed that 25 of the more than 130 features listed in GARI by the end of 2021 are assistive in nature and match the requirements laid out in the standards applicable for AT. Recent developments such as the European Accessibility Act (2019) are likely to lead to further enhancement of consumer technologies and digital services to address the needs of persons with a disability.

The research has further shown that there is potential for AT to offer more involvement in employment for people with disabilities and increase their independence. Additionally, AT available via mainstream technology, often available at lower cost than specialized AT equipment, can reduce the costs to the taxpayer and provide a good ratio of social return on investment (SRoI). Mainstream AT devices supplied to people with disabilities based on their individual needs can widen the availability of support and choices based on each individual's preference. This could be made possible by establishing AT provision on purpose and outcomes rather than an increasingly blurred distinction between accessible and assistive products. It would also help "future-proof" requirements to include new technologies such as smart speakers and wearable technologies where the help of those products is demonstrable for people with a disability.

Overall, GARI-listed devices could bridge the gap in what is provided to people with disabilities and their specific needs. The GARI list describes many devices that can be helpful to people with disabilities, keeping in mind that these devices are equipped with built-in accessibility features which are of great use and beneficial to people with disabilities. Supporting disabled people with access to AT can significantly reduce loneliness and allow them to be more active participants in society.

Over the past decade, the design of products that empower people with a disability has shifted from specialized and dedicated products designed only for those with a disability to features and functions integrated into cost-effective consumer technologies for the benefit of all. The opportunity to expand the availability of such technologies is at risk of being ignored due to models of delivery that are founded in medical devices and which have failed to reflect trends in our understanding of technology and the choices and preferences expressed by persons with a disability.

Research undertaken on behalf of the MWF (Banes 2023) demonstrates the opportunities to expand the understanding of assistive technology to include accessible consumer electronics such as mobile phones, tablets, and wearables (e.g., smartwatches), which, being mainstream, often come at a lower price than specialized AT and offer an extensive suite of accessibility features that can improve the access of people with disabilities to education, employment, public, and social life.

Official recognition that accessible consumer electronics can help bridge the gap and lack of access to assistive technology created by cost and complexity can also improve access to AT services, including training, technical support, and matching people to technology. Such support and recognition would be a powerful boost to raise awareness and expand the understanding of how to deploy these technologies to support people with disabilities effectively.

Declarations

This content is solely the responsibility of the author and does not necessarily represent the official views of ATIA. The authors disclosed financial relationships with GARI. GARI is an initiative of the Mobile & Wireless Forum (MWF), an international association of companies with an interest in mobile and wireless communications, including the evolution to 5G and the Internet of Things. Its members include Apple, Cisco, Ericsson, Google, Honor, Huawei, Intel, LG, Motorola Mobility (Lenovo), Motorola Solutions, Qualcomm, Samsung, Sony and Zebra. More information about the MWF and its activities can be found at mwfai.org. The GARI project is open to non-member participants and currently has over 30 manufacturers participating: gari.info. David Banes disclosed two non-financial relationships. He is an ATIA Leadership Strand Adviser and a member of the Editorial board of the Assistive Technology Outcomes and Benefits journal.

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Voices from Industry

Revolutionizing Augmentative and Alternative Communication with Generative Artificial Intelligence

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Abstract

Generative AI, a type of Artificial Intelligence (AI), is set to revolutionize Augmentative and Alternative Communication (AAC). New AAC devices powered by this technology will enable non-speaking individuals to engage in real-time conversational speech, bridging the gap between AAC users and non-AAC users in daily life. The breakthrough lies in the ability of this AI to rapidly generate human-like text using contextual prompts. Generative AI, integrated with existing technologies like text-to-speech, facial recognition, and eye tracking, will unleash new possibilities for time-relevant, effortless, intuitive, and personalized communication for individuals with complex communication needs. The technology needed is currently available or in development, and companies are rapidly moving to bring these products to the market. We are on the verge of a disruptive revolution that will reshape most aspects of life and open doors for AAC users that have been largely closed until now.

Keywords: augmentative and alternative communication, generative AI, artificial intelligence, communication rates

Revolutionizing Augmentative and Alternative Communication with Generative Artificial Intelligence

A particular type of Artificial Intelligence (AI), called Generative AI, will revolutionize the Augmentative and Alternative Communication (AAC) domain. Soon, a new breed of AAC devices will help to break through the barrier that has separated non-speaking individuals from general society for too long. These devices will place the long-sought goal of real-time conversational speech within the reach of individuals with complex communication needs. This revolution will take advantage of a recent breakthrough in the field of AI: the ability to easily and quickly generate unique, yet relevant, human-like text using a few contextual prompts. This technology is called “generative artificial intelligence.”

While Generative AI is the linchpin of the architecture described in this article, a few additional technologies are needed to fulfill this vision. Fortunately, these technologies already exist. They simply need to be assembled and tuned. Many of these technologies, like text-to-speech and eye tracking, have been around for years, but recent advances have rendered them almost magical. Companies that have built up expertise in traditional AAC devices and services over decades will need to retool and retrain quickly to accommodate these changes in much the same way that camera and film companies had to reinvent themselves upon the arrival of digital imaging.

Waller (2019) predicted that unlocking the inherent value and promise of individuals with complex communication needs would require a paradigm shift in the design of AAC. Sennott et al. (2019) recognized that artificial intelligence might very well be the basis for that shift. Because these authors published in 2019, they could not have known about the qualitative change in AI that would burst onto the scene a few years later. Rather than opening up new possibilities for intelligent word prediction and encodings based on contextual clues and specialized situational logic, the application of prodigious amounts of computer hardware and training data has made it possible to generate entire thoughts, both relevant and personalized, in seconds (Hwang & Chen, 2023).

The technology described in this article is either readily available or currently in development. Companies are moving at a dizzying speed to bring these products to market. As such, the statements and recommendations included here must be prefaced with the words “for now” or “currently.” We have suddenly reached the inflection point in the advance of information technology predicted by Ray Kurzweil (2005, p. 11) almost two decades ago.

...we won't experience one hundred years of technological advance in the twenty-first century; we will witness on the order of twenty thousand years of progress (again, when measured by today's rate of progress), or about one thousand times greater than what was achieved in the twentieth century.

Target Audience and Relevance

This article is relevant to several audiences — AAC users, AAC vendors, AAC service providers, and AAC researchers. AAC users will learn that the capabilities of generative AI, that are currently benefiting individuals throughout society, can and will support them in demonstrating their inherent value and talents, along with putting them in settings where they can influence the thinking of others. AAC vendors and service providers will get a glimpse into the future of the industry, along with the skills they will need to develop and the technologies they will need to incorporate. AAC researchers will be inspired to explore entirely new approaches and, like the AAC vendors, create new alliances and collaborative relationships.

Disclaimer

In the interest of full transparency, I am neither a developer nor researcher of artificial intelligence, nor an expert in psychology, neurobiology, linguistics, conversational analysis, or augmentative and alternative communication. Instead, I have a three-decade history in designing and developing software and hardware products as a systems engineer at AT&T Bell Laboratories and its subsequent divestitures. That work included consulting with telecommunications companies and vendors to understand their current capabilities, describe their embedded operational systems, document requirements for new functionality, and direct the development of complex products involving multiple existing and custom components.

Communication Types

Table 1 represents attempts to organize human communication into three categories as a function of the time delay between information exchanges. This approach uses the categories and terminology associated with data processing (system-to-system data exchange) as a helpful model for categorizing types of human communication.

Table 1: Human Communication Types

Type	Delay Between Exchanges	Examples
Real-Time	instantaneous to a few seconds	voice/video calling, face-to-face spoken or signed interactions
Near-Real-Time	tens of seconds to a few hours	chatting, messaging
Batched	a few hours to days	email, letters, voice/video recordings

Communication forms like books, college lectures, graffiti, and bumper stickers are almost entirely one-directional and, as such, have an indeterminate exchange delay. On the other hand, body language can communicate emotional states in fractions of a second, but the construction and interpretation of the exchanges are mainly unconscious. Note that in the case of real-time communication, the delays between exchanges can even be negative, such as the interruption of, or speaking over, the questions and responses of others.

Each of these communication types can be used to establish, reinforce, and maintain personal relationships or to persuade others to adopt a particular point of view. However, the shorter the exchange and the more in-person a communication type, the more clarifying, reinforcing, and persuasive the interaction can be. More

delayed or remote exchanges can be useful when first establishing relationships and later when maintaining them.

Real-time exchanges represent the vast majority of interactions that take place in society. Anyone who cannot participate in these interactions will often be relegated to the periphery of community and relationships. Developing influence can begin through batched communication like letters to the editor, business proposals, or white papers. However, eventually, one will need to restate the core of the argument in person and in real-time to the people with power. Without this ability, individuals are often relegated to positions of little influence. Unfortunately, individuals who use AAC devices rarely progress beyond transactional to interactional communication (Waller, 2006). Waller defines transactional communication as “expressing concrete needs/wants and transferring information” (p. 221). Interactional communication is defined as “telling jokes, sharing experiences, discussing philosophy, etc.” These definitions were originally proposed by Cheepen in 1988. Waller emphasizes that interactional communication is critical to develop and maintain relationships but is significantly more complex than transactional communication, with AAC systems primarily supporting the latter. Waller indicates that little has changed since 2006 by restating this position in her 2019 article.

Near-real-time exchanges are odd because they fail to fulfill either goal of establishing or maintaining relationships. While popular today, they are a recent invention, too terse for establishing relationships and too distant for maintaining them. Their information payload is too small to make a convincing point and too remote to communicate the non-verbal cues that humans have evolved to detect and internalize.

Communication systems for individuals with disabilities have, for decades, focused on giving people a voice. Initially, the concern is to support the individual in saying “something, anything,” that can communicate a need or a preference. Next, the goal moves to expanding their access to and use of a larger and larger vocabulary so that their needs and preferences can be expressed in richer and more personal ways (Waller, 2019). Unfortunately, support for more extensive vocabularies in AAC devices is typically accompanied by a requirement to possess or develop complex cognitive and operational skills.

The technologies available for these augmentative and alternative communication (AAC) systems can only communicate in near-real-time or batch modes. An AAC user, if given enough time, could surely prepare a speech in advance of an event and then play that speech on cue; however, as soon as the nature of the communication changes to a real-time format—say, a question/answer session—the quality of communication tends to fall dramatically due to the sizable delays introduced by the AAC system and the individual’s motor abilities.

At times like these, non-AAC user communication partners with insufficient or no AAC knowledge inevitably engage in several negative behaviors. Non-AAC users will interrupt, attempt to complete the AAC user’s thoughts, preempt communication from the AAC user, and even discuss what the AAC user intends without involving the AAC user. This behavior often leads to misunderstanding, simplification of ideas, and disengagement by both sides of the discussion. Most importantly, this inequitable dynamic marginalizes, silences, and restricts the self-determination of the AAC user.

Speech Rate

Speech rate is calculated as the average number of words spoken per minute. Alternatively, it may be more accurately calculated as the average number of syllables per minute, since speech often involves words that vary significantly in their number of syllables. Since pre-literate users of AAC systems normally select words rather than syllables, we will focus here on words per minute (wpm). Note that AAC users can only convey the words or concepts that are available to them via their AAC device.

Typical rates of speech vary with the kind of communication taking place, but here are some commonly quoted numbers:

- Presentations: between 100–150 wpm
- Conversations: between 120–150 wpm
- Audiobooks: between 150–160 wpm
- Radio hosts and podcasters: between 150–160 wpm

With a lower bound of 100 wpm for presentations and 120 wpm for conversation, it is probably safe to assume that a speech rate of 80 wpm is close to the lower bound for comfortable conversation. Note that AAC users with significantly limited mobility, especially those using eye gaze as a selection method, normally average between 10 and 20 words per minute (Morris, 2021), more than five times slower than what might be considered functional in a typical conversation.

If we assume that an AAC device requires about half a second to speak a single word, then an AAC user has $60 - 80 \times 1/2 = 20$ seconds to select those 80 words. That is just $80/20 = 1/4^{\text{th}}$ of a second, on average, to choose each word to maintain an 80-word-per-minute rate. This is admittedly a rough calculation with rough assumptions, but it can be helpful as a ballpark figure.

If a slower speech rate is workable, then there will be additional time for word selection, but there is a limit if one wishes to be understood. If it regularly takes more than one or two seconds to select and voice each word in a sentence, it becomes difficult for the listener to retain and remember the string of words as a whole and to understand what is being said. When a collection of words is strung together in connected speech, the average time to speak each word goes down significantly. However, one must then consider the time required to prepare the string of words in the first place.

Literate users of AAC systems may choose to construct their responses by selecting letters from a physical or virtual keyboard. This gives them access to the entire language but often at a reduced rate of word construction due to a limited range of motion or poor hand function (von Tetzchner, 2018). In a review of relevant research, Koester and Arthanat (2018) found an average speed of 1.7 wpm for individuals employing onscreen keyboard scanning and selection using a switch. Letter selection using eye-gaze can improve text production to 8 to 10 wpm (Waller, 2019). Semantic Word prediction can increase communication rate but incurs a visual scanning cost (Trnka et al., 2007). Compaction (Baker, 1982; 1987) and other encoding strategies like Context-Aware Abbreviation Expansion (Cai et al., 2022) can increase an individual's word production but are accompanied by significant cognitive requirements. Note that a 50% to 100% improvement in speed, given a base rate of 10 wpm, produces only 15 to 20 words per minute and is still insufficient for real-time conversation.

Silence is NOT Golden

However, I believe focusing on words per minute is a red herring. In reality, the mismatch between an AAC user and a non-AAC user in conversation is fundamentally the result of a deeply rooted human aversion to “awkward” silence.

It is uncommon for English-speaking individuals to experience more than a moment of silence between exchanges during a conversation, with typical pauses in turn-taking lasting between a quarter and half a second. If the silence persists for longer than a few seconds, it tends to make people uneasy or disrupt the natural flow of the discussion. Research conducted by Koudenburg et al. (2011) revealed that, in the United States, we become uncomfortable in conversation after just four seconds of silence, and sometimes as little as one second of silence (Jefferson, 1989). Repeatedly encountering multi-second delays in a conversation can cause reactive and anticipatory anxiety in the listener, leading to the kind of conversational sabotage (however unintended) described earlier. Police interrogators regularly take advantage of this aversion to silence and can get suspects to reveal more than they otherwise would simply by sitting quietly and looking at the suspect for extended periods.

Imagine for a Moment

Now, imagine the hypothetical scenario presented in Table 2. Tom and Mark are old friends, and both like coffee. They encounter each other at their local Starbucks. Mark is a non-speaking AAC user, and Tom initiates a conversation. What follows is a relatively formal description of the beginning of their conversation. Suspend your disbelief for a moment.

In the table, Tom’s statements are in the column labeled “Tom,” and Mark’s statements are in the column labeled “Mark.” The sentences in the column labeled “AAC Device Display” are shown on Mark’s AAC device after each of Tom’s statements. The timestamps mark the end of Tom’s statements and the start of Mark’s. The timestamp marks the time at which the AAC’s display has finished updating. The bold statements represent the response option selected by Mark. Both Tom’s and Mark’s statements are verbalized. In Mark’s case, the verbalization is produced by his AAC device.

Table 2: An Example of Facilitated Conversation

Time	Tom	AAC Device Display	Mark
0:00	Hi Mark, how are you doing?		
0:05		<ol style="list-style-type: none"> 1. I'm having a slow morning. I need coffee. 2. About as well as the Yankees. They've lost their last three games. 3. I'm fine. How about you? 	
0:08			I'm having a slow morning. I need coffee.
0:10	You and me both!		
0:15		<ol style="list-style-type: none"> 1. How is your son doing in basketball? 2. You haven't told me about your trip to Disney. 3. Are you OK? 	

Time	Tom	AAC Device Display	Mark
0:18			Are you OK?
0:21	Yeah, I'm fine, just sleepy. I was up late last night watching Netflix.		
0:26		<ol style="list-style-type: none"> 1. What show were you watching? 2. By yourself or with your son? 3. I don't have Netflix; is it worth the price? 	
0:31			By yourself or with your son?

In a little over 30 seconds, Tom and Mark had three exchanges and further cemented their relationship. There is a 3- to 10-second delay between the end of each of Tom's statements and the start of Mark's reply. During that time, Mark is presented, via his AAC device, with three options to respond to Tom. Mark selects his preferred response, which causes that sentence to be vocalized by his AAC device. Later, Mark will provide feedback to his AAC device indicating why he preferred the responses that he did. In particular, he will indicate that he is currently interested in learning more about the relationship between Tom and his son. The next time Tom and Mark meet, the device will provide more response or conversation initiation options to lead the conversation in that direction. It will offer those suggestions earlier or first in the ordered list. Mark's AAC device serves as an interface to a local or cloud-based service that understands a great deal about Mark and his relationships. Its goal is to help Mark participate in real-time, turn-taking vocal conversations in arbitrary settings with acquaintances and strangers. It strives to give Mark a voice that best represents his worldview, kindness, sense of humor, and idiosyncrasies.

What is Going On?

Is this science fiction? Not at all. This scenario leverages technology that, for the most part, is available today. Of all of those technologies, the key one is generative AI. Without it, there would be no response options for Mark to choose from. However, before looking at the available technologies, let us explore the details of one of these exchanges.

Table 3: The First Exchange

Time	Tom	AAC Device Display	Mark
0:00	Hi, Mark, how are you doing?		
0:05		<ol style="list-style-type: none"> 1. I'm having a slow morning. I need coffee. 2. About as well as the Yankees. They've lost their last three games. 3. I'm fine. How about you? 	
0:08			I'm having a slow morning. I need coffee.

At time 0:00 in Table 3, Tom initiates the conversation with the statement, "Hi Mark, how are you doing?" This action is much more complex than it appears at first glance. It is valuable to examine the two phrases in his sentence separately. The first phrase, "Hi Mark," embodies multiple activities:

1. Tom must first recognize Mark's presence in this setting and then confirm that this individual is a person with whom he is in a relationship.
2. Tom then calls out, "Hi, Mark," either in an attempt to get Mark's attention or to acknowledge that he has Mark's attention.
3. Once he has Mark's attention—generally in the form of shared eye contact—he generates and voices a greeting that is appropriate for the setting and the amount of time that has passed since he last interacted with Mark. Because Tom is a speaking individual, he can unconsciously generate human-interpretable speech.

This may seem like an overly detailed description of Tom's greeting, but Mark and his device will also have to accomplish these things if he would like to initiate a similar conversation in a similar setting.

In response, by time 0:05, Mark's AAC system must:

1. single out Tom's statement from the surrounding conversations and noise,
2. recognize Tom as the speaker and understand Tom's relationship to Mark,
3. convert Tom's utterance from voice to text and parse the words into a meaningful form using natural language processing,
4. generate three appropriate responses for Mark to choose from, with what would likely be Mark's preferred selection appearing first, and
5. display the responses on Mark's AAC device (or use text-to-speech to play the choices to Mark in order of likelihood of selection).

An appropriate response, in addition to being representative of Mark's relationship with Tom, could take into consideration the following factors and thereby improve the relevance of the provided responses:

- the location,
- time of day,
- Mark's conversational style and preferences,
- Mark's state of mind and a prediction of Tom's state of mind,
- any goals Mark may have as part of his relationship with Tom, and
- recent conversations between Mark and Tom.

By time 0:08, Mark has made his selection among the options provided to him, and the AAC system must voice that response at a volume level appropriate for the ambient noise level of the setting. The system must include the proper inflection in its vocalization to ensure the maximum amount of information and meaning is communicated.

This process then repeats until one or both individuals indicate a desire to terminate the conversation, at which point, the exchange goes into a wrap-up phase. Note that people often use a verbal blocking technique to hold the conversation while they prepare their response. Words and phrases like "just a second," "you know," "um," "I think," and "that's a good question" are an indication that the individual is deciding on a response, and it would be inappropriate to interrupt them. Such utterances are not to be interpreted as a response in and of themselves. Having the system automatically generate these placeholders may be helpful while the user is choosing among the offered responses or preparing a response from scratch.

Providing Feedback to Improve Performance

Later that day, when Mark has spare time, he reviews his recent conversations and shares his feedback with his AAC device. He critiques the suggested responses regarding both their form and their presentation order. He explains what the device failed to consider in generating responses. This information is then used to modify the “tendencies” of the device and improve its performance in future conversations with Tom and others.

Functional Components of this Scenario

Even to a non-linguist, an overwhelming number of complex tasks must be successfully executed to participate in what looks, at first glance, like a trivial conversation. Most of them appear to take place subconsciously but would have to be explicitly constructed if carried out by a machine. Here are the tasks that stand out.

Preparing for Conversation

1. **Location recognition.** The conversation's physical location often sets the conversation's foundational context, especially when interacting with strangers.
2. **Partner(s) identification/recognition/selection.** At a fundamental level, the communication partner or partners must be identified. That information can then be used to determine the kind of relationship that exists between the participants.
3. **Relationship recognition.** The speakers may be strangers, close friends, or family members.
4. **Partner relationship history.** By knowing the nature of past interactions, it is possible to make predictions about the nature of the current exchange.
5. **Communication goal identification.** Every conversation is entered into intentionally, and each participant has a goal, for example, to reinforce a friendship or persuade a customer to purchase a product.
6. **Goal achievement tactic selection.** For any but the most mundane conversations, some planning must take place regarding how the exchanges within that conversation will be directed.

Initiating the Conversation

1. **Attention capture.** In this step, the conversation's initiator gets the communication partner's attention by saying or doing something. A spoken greeting is an example of capturing the attention of a communication partner.

Turn-Taking

1. **Speech recognition.** There are two fundamental elements to speech recognition. The first involves separating the sound waves of interest from the ambient noise, and if multiple individuals are involved in the conversation, one must attend to all speakers individually. The second element is to parse the sound waves into words, phrases, and sentences.
2. **Conversation continuation.** One turn in a conversation can build on previous turns because the content of those turns is remembered, at least for the duration of the conversation.
3. **Interpretation of facial expressions and body language.** Proper interpretation of the conversation partner's facial expressions, micro-expressions, and body language can be critical to deciding whether a conversation should be stopped or started and whether, at some point, it should be redirected. This information can give the participants information about each other's emotional and intellectual states moment by moment as the conversation progresses.

4. **Response generation.** While this is listed as just a single element of turn-taking, it is where all the heavy-duty intellectual work occurs. It requires integrating and synthesizing all current and historical information relevant to the conversation. Consideration may also be made for cultural influences, emotional dynamics, and social context.
5. **Speech generation with inflection.** The ultimate goal of the AAC system is to render the user's thoughts in the form of audible speech. In addition, the meaning of a set of words can vary greatly depending on which words are emphasized or how the pitch of the speaker's voice changes along the way.
6. **Attention maintenance.** Small utterances of agreement/surprise, head nods, and facial expressions can help maintain the connection by demonstrating solid relationships between the communication partners.

Terminating the Conversation

1. **Termination choices.** Partners must be able to communicate that each has met their conversational goals and that their conversation is now ending. Sometimes, the individuals commit to further discussion and what that conversation may entail.

Relevant Technology

It must be possible to accomplish all of these functions through the application of technology. Many of the technologies listed below have been around for years, but all have significantly improved in accuracy, miniaturization, capacity, and speed.

Situational Awareness

- **GPS.** The accuracy of public GPS receivers depends on weather and obstructions but is typically on the order of 5 to 10 feet. That is more than sufficient precision to determine the physical location in which one is currently situated.
- **Electronic calendars.** By recording your plans about whom you expect to meet and where you expect to meet them in your online calendar, this information can be made available to the system to set expectations for any conversation in which you may be involved.
- **Facial recognition.** Current facial recognition algorithms can predict an individual's identity with over 99% accuracy based on an image of their face. This accuracy is reflected in the fact that many people use facial recognition instead of passwords to log onto their computers and phones.
- **Voice recognition.** A machine's ability to recognize a particular individual based on characteristics of their voice is currently performed with over 98% accuracy and is regularly used during phone conversations with financial institutions to establish the account holder's identity.

Natural Language Processing (NLP)

- **Speech-to-text** is the act of interpreting audio signals produced by the speech of an individual and converting them into a text representation. Current algorithms are 90 to 95% accurate, depending on environmental conditions. Microsoft claims to have a "word error rate" (WER) of 5.1%, while Google boasts a WER of 4.9%. This is comparable to a professional human transcriptionist at 4%.
- **Text-to-speech**, sometimes called speech synthesis, is a technology that can take text as input and produce results indistinguishable from human speech – including sex and age differences, regional accents, and voice inflection.

- **Chatbots** are computer programs designed to simulate a human conversation. They have been used for decades and specialize in retrieving structured information that has been predetermined based on the industry in which the chatbot will be deployed. A simple chatbot will not support open-ended conversations.
- **Sentiment and emotions analysis/classification** uses computers to find and classify emotions in a body of text as positive, negative, or neutral based on the opinions expressed.

Statement/Response Generation

- **Large Language Models (LLM)** are deep-learning algorithms that use huge datasets to recognize, summarize, translate, and predict textual language.
- **Generative AI** is a type of artificial intelligence (AI) that can assemble text, images, or other media from scratch when given instructions or prompts. Generative AI systems normally have an LLM at their core.
- **Relationship modeling** is used in social psychology. Relationships exist as a social connection, link, or tie between two or more people. A relationship model is a formalization of these relationships as nodes (individual people) and connections between the nodes (the nature of their relationships).
- A **worldview** is a set of ideas and beliefs about the world, oneself, and life as a whole; a group of personally tailored theories about how the world works and answers to a wide range of questions. A **worldview model** is a formalization of these beliefs and ideas into a structure representing a particular individual's thoughts and preferences.
- **Response shaping** is the process of teaching or training an organism (or, in this case, a large language model) to generate a specific response by rewarding responses that are close to or match the response one wants it to provide.

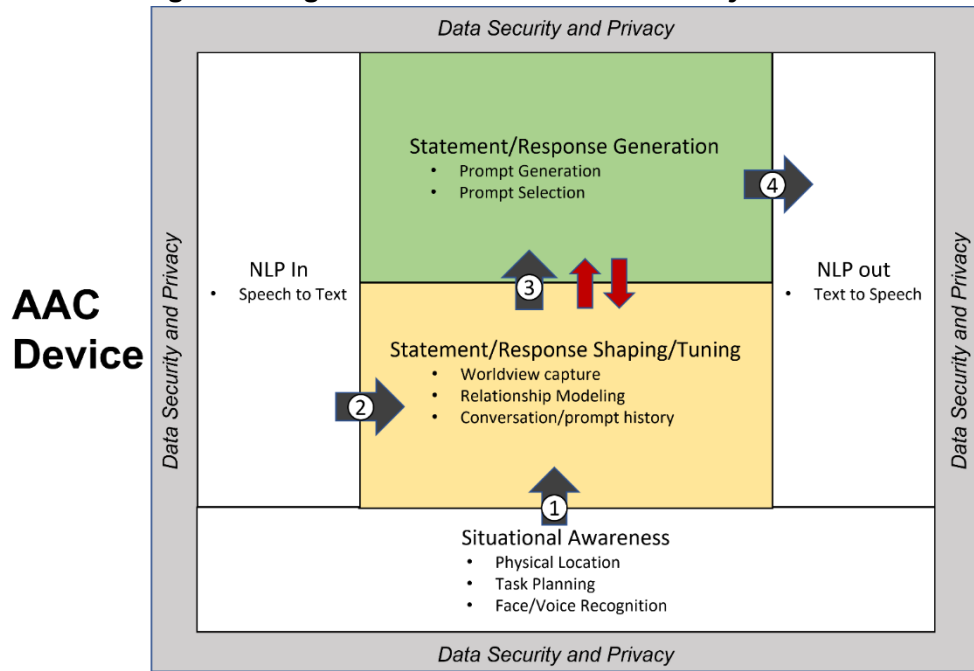
User Interface

- **Tablet/Laptop computers and smartphones** are the most common hardware platforms for use in AAC. They have several built-in capabilities that can make them an excellent starting point for AI-driven communication: microphones, cameras, visual displays, and speakers. Many include GPS receivers and switch access features as well.
- **Eye tracking** is a technology that attempts to determine what a person is looking at by identifying and following the movement and location of the person's pupils. This information can then be used to select among targets in the person's visible surroundings—in particular, potential communication partners.
- **Augmented Reality (AR)** overlays a computer-generated image on an image of the real world to literally "augment" reality. AR goggles or glasses could combine the user's view of their current (or potential) communication partners with AI-generated statement/response options. If the goggles or glasses can monitor the location and movement of the user's eyes, then selecting partners and selecting responses could be driven directly via eye movements.
- **Switch-based selection** is a collection of technologies that recognize an individual's intentional muscle movement by closing of an electric circuit. The movement is then tied to choosing an option in an associated user interface through direct selection or selection scanning methods.

High-Level Architecture

Figure 1 shows a 30,000-foot description of how these technologies might fit together to provide the functionality needed for facilitated real-time communication. Boxes that share a border exchange information. The arrows represent the flow of that information. The large black arrows represent the flow of information that takes place during conversations. The smaller red arrows represent information flow that takes place during system feedback, training, and tuning sessions.

Figure 1: High-Level Architecture – Entirely Local



All boxes are wrapped in a data security and privacy strategy. Because the system is intended to represent a repository of the user's thoughts, opinions, and goals, the data is inherently private and must be protected.

Since this is fundamentally a tool for verbal conversation, both the input and output NLP boxes (on the left and right) are responsible for taking speech as input and generating speech as output. This technology has been around for decades, though it has advanced tremendously. High-quality, speaker-independent speech recognition is now possible, as evidenced by the abundance of "smart speakers" with which we surround ourselves. Note that the recognition can occur in relatively noisy environments and can be associated with a particular individual in order to provide custom responses. Speech generation has, similarly, seen incredible advancement to the point where generated speech sounds completely lifelike and incorporates all the necessary voice inflections.

Functions in the "Situational Awareness" box gather information about the environment to set a context for the conversation. Conversation in a coffee shop is likely to involve brief exchanges with strangers. In contrast, discussions in the workplace are likely to be lengthier, with a need to be sensitive to particular protocols and power dynamics.

The two boxes in the center are where the "sausage" of conversation gets made, and they must work closely together. The "Statement/Response Generation" box is responsible for creating a finite set of reasonable and grammatically correct response options for the user. This box would be implemented using generative artificial

intelligence via a large language model. Creating reasonable and grammatically correct text is where large language models already shine. This box is the key to revolutionizing AAC and propelling AAC users into the center of society. The second box, "Statement/Response Shaping/Tuning," is critical to generating suggested responses that are appropriate for the setting, topic, and communication partner. Most of all, this box ensures that the suggested responses are representative of the sort of things that this AAC user would want to say.

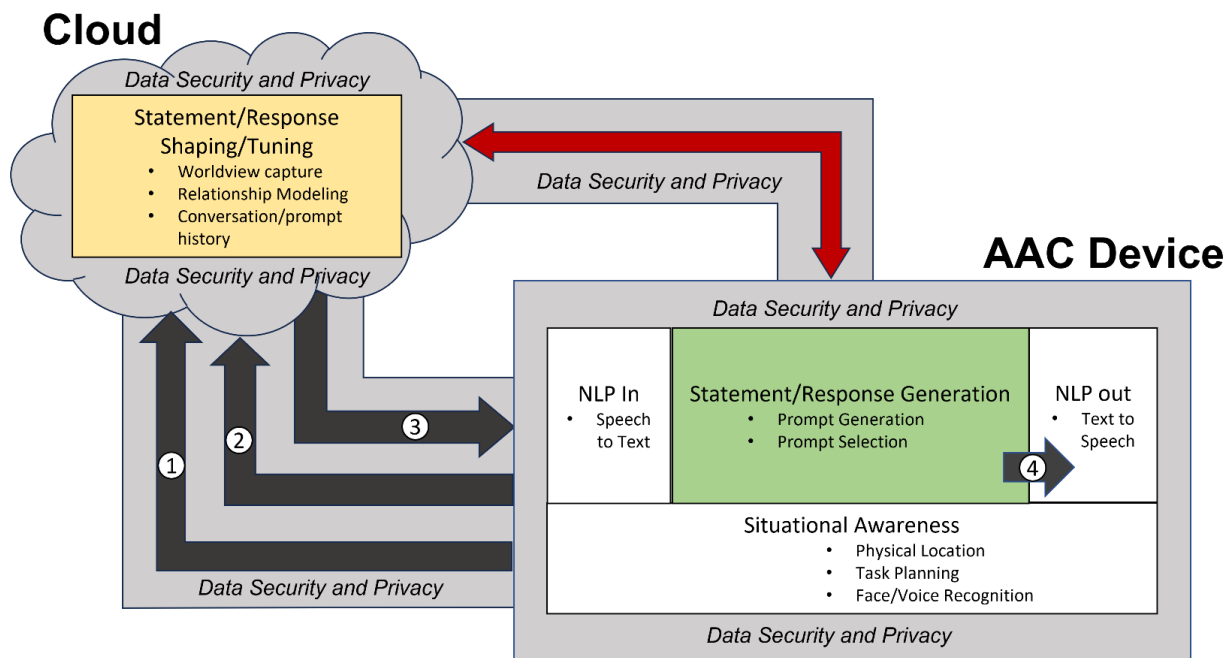
The typical information flow between the architectural components starts with:

1. the context for the conversation coming from the Situational Awareness component,
2. that is then combined with a text representation of what the communication partner has said as processed by the NLP In component,
3. the AAC user's worldview processes both of these pieces of information, and a request for a set of goal-oriented response options is made of the Statement/Response Generation component, which is then presented to the AAC user,
4. the selected response is passed to the NLP Out component for conversion into quality human speech.

This flow repeats with each exchange in the conversation.

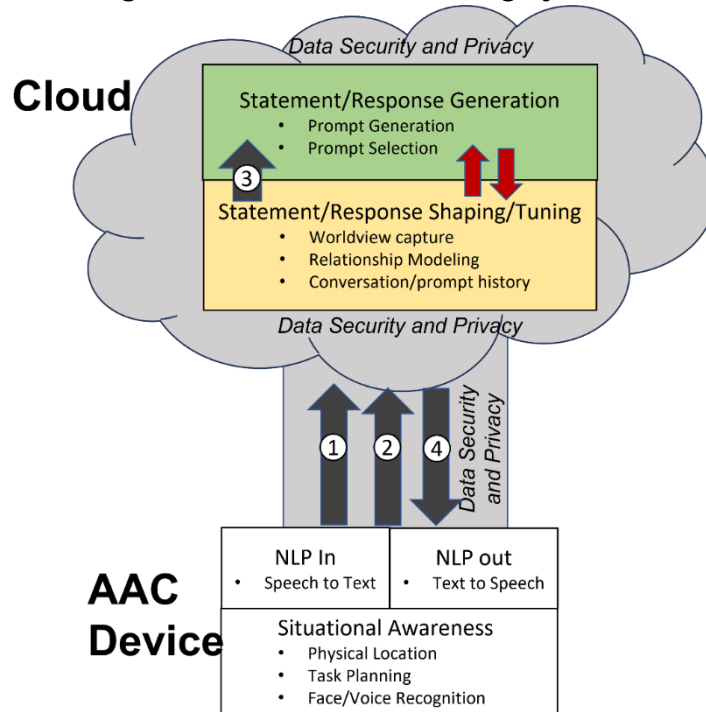
The architecture in Figure 1 puts all functionality directly on the AAC device. This limits protected data flow into and out of the device—thereby reducing security concerns—but places significant hardware and software requirements on the AAC device itself. Figure 2 shows the same components but with the Statement Response Shaping/Tuning component moved to the cloud, possibly for greater functionality or speed.

Figure 2: High-Level Architecture – Local and Cloud



This architecture has a greater need for data security and privacy, both surrounding the individual components and the communication between them. Also, the greater processing speed available in the cloud could be nullified by the communication delays introduced between the cloud and the AAC device. Finally, Figure 3 shows the two most sophisticated and processing-hungry components moved to the cloud.

Figure 3: High-Level Architecture – Largely Cloud-based



This architecture has several advantages over the other two. The cloud can provide the two components with the greatest computational requirements access to the most powerful computer hardware available. By locating these logically sophisticated components in the cloud, one can ensure that they are updated regularly with the latest programming, regularly backed up, and can take advantage of the latest data security/privacy software. By moving these processing-heavy components to the cloud along with the data requiring the most protection, the AAC device itself can be much simpler. Note that mapping functionality to physical hardware is a challenging exercise in practice and even more of a moving target because both the software and candidate hardware are rapidly becoming smaller, more capable, and less power-hungry.

The latter two architectures take advantage of processing in the cloud but, at the same time, place a requirement on the system to have access to the internet. Mobile broadband protocols like 5G, which are needed to support high-bandwidth applications like autonomous vehicles, will probably provide more than sufficient capacity for these designs. There may be an issue when using such a device in a school setting where internet access is more controlled.

Issues Around Privacy for Communication Partners

I specifically identify a need for data protection and privacy for the AAC device user in these architectures. To what degree must information associated with the communication partner or partners also be protected?

Every day, when we converse with others, our brains automatically and subconsciously perform “partner recognition,” both facial and voice. It would be absurd to ask these individuals for permission to remember what their faces look like or the sound of their voices. Similarly, one would not ask permission to remember what a partner said during a conversation and is often appreciated.

However, the approach described here could challenge these intuitions, primarily because the system would create and maintain a record of the specific facial and voice characteristics that made recognition possible, along with a highly accurate record of the conversation, in order to better inform future conversations with these and other individuals. Further complicating the matter is the fact that this information may need to be communicated to the cloud for storage and processing by the artificial intelligence components. These are issues that deserve further thought and, if necessary, legislation.

A Brief Introduction to Generative AI – e.g., ChatGPT

Generative AI tools like ChatGPT are based on an artificial neural network. This kind of AI is particularly good at understanding sequential data, such as sentences in a body of text, because it can pay attention to different parts of the data depending on the context (Vaswani et al., 2017). ChatGPT has been trained on a large amount of text data from the internet. This text data could include books, articles, websites, and more. It learns by predicting what comes next in a sentence and then being rewarded for correct predictions. For example, if you gave it the sentence "The quick brown fox jumps over the...", it would predict that the next word is "lazy" based on the famous English pangram it has seen frequently during its training.

Through this process of predicting the next word over and over again on a vast scale, it starts to learn not just about individual words but also grammar, sentence structure, context, and even some factual information. It also captures some of the biases in the data on which it was trained (Epstein & Hertzmann, 2023). While this process may seem reminiscent of word prediction, it is more like complete thought prediction.

When interacting with ChatGPT, you provide a request or prompt, and the model generates a continuation. It does not know or remember specific documents from its training but uses its learned understanding of language usage to generate contextually relevant and grammatically correct text. This incredible capability already contributes to increased productivity in several professions (Bowles & Kruger, 2023; Noy & Zhang, 2023). There is no reason why similar gains in productivity cannot be achieved by AAC users when this capability is accessible via their AAC systems.

The "generative" part of the name comes from the fact that it can produce new, original sentences and paragraphs based on what it has learned. It is not simply choosing a response from a set of predefined options but instead generating something unique each time, guided by the patterns it learned during training (Vaswani et al., 2017).

Generative AI systems seem to have come from out of nowhere. In reality, they have been around for a decade but were largely ineffective. In the last few years, three enabling technologies came together to create a breakthrough in artificial intelligence: cheap and powerful computer hardware called graphical processing units (GPUs), easy access to terabytes of written text via the internet, and new computer programming algorithms. These resources have steadily increased in availability and capability over time. No one in the industry can explain why the current level of computing power, data, and programming has resulted in this breakthrough.

ChatGPT is only one of the several available generative AI systems. Google has a large language model (LLM) called PaLM, and Meta (the parent company of Facebook) has one called LLaMA. Links to these LLMs are included in the Resources section of this article. It is no coincidence that these systems are associated

with the largest technology companies on the planet. The amount of computing necessary to create them, and therefore the cost, is mind-boggling. ChatGPT was created by a company called OpenAI with several investors, including Microsoft and Elon Musk.

Creating a Worldview Model

A well-designed large language model like ChatGPT is more than capable of quickly generating a collection of grammatically, semantically, and syntactically correct response options all by itself. It is one thing to give the AAC user final control over the statements spoken by the AAC system, but that alone would remove the individuality of the AAC user from the conversation. The goal of this design is not just to speak “for” the AAC user but to speak “as” the AAC user. To achieve that end, we need to exert some control over the response generator so that the proposed responses align closely with the opinions and attitudes of this specific AAC user. To do that, there needs to be a mechanism that can capture this person's personality, knowledge, and worldview. Other terms like “mental model,” “knowledge model,” “mind map,” “digital identity,” “borrowable identity,” and “personal AI clone” are sometimes used to represent the same organized collection of information about an individual.

This worldview information can then be used in at least two ways. First, it can be used to train the large language model so that it naturally prefers concept formation that aligns with the beliefs of the target user. Second, specific, detailed prompting can be provided to the model in preparation for a conversation so that its output is bent/shaped in the direction the user would prefer. The example in the next section takes the second approach.

One can imagine several ways to collect information about an individual’s worldview:

- social media contributions/selections: posts, photos, likes, watched videos, etc.,
- a review of previous writings or spoken statements,
- answers to survey questions,
- holding focused interviews to collect facts about the individual,
- holding mock conversations, and
- interviews with family and friends.

Fortunately, several researchers have already attempted to create a digital, immortal avatar for individuals. In the process, they had to first capture and organize as much information about the individual as possible. Rahnema et al. (2021) proposed an approach that combines symbolic reasoning and data learning as part of a double-loop learning system to create a:

Knowledge structure that represents someone’s intuitive perception of her environment, the relationships between different entities in the environment, and also her way of thinking or reasoning upon the perceived world.

In the Resources section below, I have included a link to a documentary called *Living Forever Through AI: Digital Immortality and the Future of Death* that highlights the work of Rahnema and his team at Ryerson University, RTA School of Media, in Toronto, Canada to create such an avatar for the documentary’s narrator.

The documentary shows one method of establishing a relationship model for the narrator by performing facial recognition on a collection of family photos.

Note that the concept of interest in this document is not the creation of an avatar for digital immortality but, instead, the collection and organization of an individual's worldview that can be used to direct the generation of personalized responses during a real-time conversation.

A Similar ChatGPT Session

Next, let us see how the Starbucks example from earlier can be simulated in a dialog with version 3.5 of ChatGPT. To hold a conversation with ChatGPT, one provides a question along with some context for that question and then asks for a response. In the first exchange shown in Figure 4, I have provided several pieces of context:

1. the location is a Starbucks coffee shop,
2. there are two individuals involved in this conversation – Tom and Mark,
3. Tom is a good friend of Mark,
4. Tom has initiated the conversation by saying, “Hi Mark, how are you doing?” and
5. ChatGPT should suggest three brief responses.

In the “future-AAC” scenario described earlier, the first two pieces of context would have been provided by the “Situational Awareness” component of the architecture, the third piece would come from the Relationship Model, the fourth piece would come from the “NLP In” component, and the last piece would appear in the AAC device's user interface.


Figure 4: Responding to a Request for Conversation Using ChatGPT 3.5







ChatGPT can generate these three potential responses in less than a second. They would be displayed on the target AAC system screen or announced to the AAC user audibly.


In the following exchange with ChatGPT, and shown in Figure 5, I provide the response Mark has selected and Tom's corresponding statement. Additionally, in suggesting three new responses for Mark, I add that ChatGPT should consider Mark's goal in this conversation to learn more about Tom's basketball-playing son. This information about Mark's conversational goal when in dialogue with Tom would come from Mark's "Worldview" and is available to the system as soon as it understands that Mark will be involved in a conversation with Tom.


Figure 5: Continuing and Directing the Conversation Using ChatGPT 3.5

 Mark responds, "Hey there, Tom! All good, thanks. How's life treating you?" and Tom says, "I'm really beat, I had a long night last night." Tom's son plays basketball for his high school team. Mark would like to learn more about how Tom's son is doing. Please suggest three possible brief responses for Mark to say.

 Certainly! Here are three possible brief responses for Mark to inquire about Tom's son's basketball endeavors:   

1. "I understand, Tom. By the way, how's your son's basketball season going? Any exciting games or standout moments?"
2. "Hey, Tom. How is your son doing on the basketball team? I remember you mentioning his passion for the sport. Any recent achievements or upcoming matches?"
3. "Speaking of long nights, how's your son managing with his basketball commitments? I recall he plays for the high school team. Any interesting developments or memorable games?"

 Regenerate response

Send a message. 

As before, ChatGPT can generate these potential responses in less than one second. By putting Mark in the critical position of selecting among the responses, he maintains control of his half of the conversation. Mark can also provide feedback to the response generator after the fact to further shape, tune, and personalize the suggestions. For example, Mark can say that one does not play a basketball "match." One plays a basketball "game." Ultimately, the goal of both the system and Mark is for the first suggestion to be the most appropriate of the three and, therefore, be visually or audibly available to vocalize first.

There may be situations where more or fewer suggestions would be presented or can be immediately requested. The user interface must also include a "free form" response generation capability as an ultimate fallback.

The feedback process would reduce the need for these alternatives over time as the system becomes more and more effective at predicting Mark's preferred responses.

Personal Autonomy

It would be natural to question whether such an AAC system would put words in the user's mouth or limit their ability to advocate for themselves. The answer to those questions depends on the level of control that the user of the system has over the range of available vocabulary and possible concepts that the system can produce.

1. At a superficial but critical level, this proposal specifies that the user interface should include a fallback capability so that the individual can create a response from scratch.
2. Because such a system has access to the entire language—either those words available to the AI or those that user can construct — the AAC user is not limited to the words or phrases that happen to be programmed into the AAC device.
3. For the “AI-prepared” responses, the individual is the final arbiter of the response that is spoken. A good user interface design would support generating three (or more) new options if the first three did not quite fit the situation. The individual may still choose to go with a less-than-optimal response in the interest of time.
4. The fundamental goal of the system is to speak “as” someone, not “for” someone. That is where the training/tuning and worldview capture come in. This is why follow-up with the AI is critical to improving the suggestions over time.

Another question might be whether a user of the system could be tempted to respond with the first statement offered by the system in the interest of time and thereby lose a measure of autonomy. We encounter a similar decision many times a day when we cannot quite think of how we want to say something or what word to use. If we sense that the conversation will be derailed or terminated if we do not say the one thing that has come into consciousness—no matter how inadequate—we usually go with that option. Smartphones offer functionality that is very much like this when texting. The messaging app will suggest entire responses that can be sent simply by tapping them. They are relatively generic, but they are usually reasonable responses and are less time-consuming and error-prone than generating a response from scratch using the small, virtual keyboard or a smartphone.

Such generic but reasonable responses are a common and critical component of everyday conversation with strangers and acquaintances. “Speaking” them with speed and fidelity could be a highly desirable capability for AAC users. However, by fine-tuning the system through an ongoing review with the AI, the user can increase the probability that the initial response proposed is also the most appropriate.

Is This Approach Only Relevant for Literate Users?

The online Merriam-Webster dictionary defines “literate” simply as “able to read and write.” So, the natural interpretation of this question would be, “Must someone be able to read and write in order to use such a system?” The examples above all assume that the words spoken by the communication partner and the response options presented by the device would be textual, therefore requiring the user to be able to read. However, one can easily imagine a feature whereby the response options could be spoken in a manner similar to auditory scanning. In addition, current LLMs are very good at restating concepts at an alternative grade, age, or Lexile level to match the user's abilities. Lastly, one can imagine the LLM translating the communication partner's speech and the suggested responses into a pictographic representation using some standard or personal graphic image set, which would extend these capabilities to even preliterate individuals.

Roadmap: How Such a System Could Roll Out

As mentioned, this is primarily a story of bringing available technologies together and connecting all the internal wiring. I would expect that the initial components would be the Speech-to-Text => Statement/Response Generation => Text-to-Speech components, which could reside on a user's laptop or tablet. This design would support the real-time generation of reasonable-sounding spoken responses to spoken statements for an arbitrary communication partner. This functionality alone would be a breakthrough in societal integration for AAC users.

Next in the rollout, elements of the Situational Awareness component could be incorporated so that response recommendations would better fit the location associated with the conversation and the partner with whom the conversation is taking place. Standard responses might also be added to the mix, which are statically tied to a particular physical location (e.g., preferred Starbucks coffee order) or conversation fillers (e.g., "Hi, how are you," or "Just a second while I think about that.").

The component that needs the most work and is the most significant challenge to integrate with the others is the Statement/Response Shaping/Tuning component. This functionality will probably come last. In addition to agreeing on a computer-accessible representation of the user's worldview and relationships, gathering this information and giving the user a way to modify and tune it will be challenging. Most challenging task will be securing and ensuring the privacy of this information. That effort will be complicated because putting this processing into the information flow will probably require more computing power and necessitate moving some of the data and processing to the cloud.

Fortunately, at each stage of development, the system adds demonstrable value and is usable as is. Having all components in place and functioning at the highest levels is unnecessary for the system to provide compelling capabilities.

Outcomes and Benefits

So much of the daily life of AAC users is constrained to communication of basic needs and preferences and only with dedicated communication partners. Due to the limitations of their AAC devices, these individuals are separated from the most vibrant and fulfilling aspects of society: real-time interactions with friends, acquaintances, and strangers. We sit on the cusp of a revolution in all aspects of our lives due to the advent of powerful, generative AI. We should expect that work, lifestyles, relationships, and technology will change to accommodate this disruption. AAC is no exception. In this article, I have laid out a case for how and why AAC devices of the near future will incorporate the capabilities of generative AI to provide a real-time voice for people with complex communication needs. In 2013, Judge and Townend surveyed 43 users of AAC devices and 68 AAC professionals to understand the factors related to AAC abandonment. The results of the survey could be boiled down to the systems being:

- hard to use and non-intuitive,
- hard for others to understand because of poor-quality voices or lack of volume control,
- a slow communication rate.

Waller (2009, p. 163) added that,

One of the reasons for the lack of extended conversation is that the design of most augmentative communication systems focuses on the communication of needs and wants. The ability to engage in more complex types of communication, including the sharing of personal narrative seldom develops in people who have grown up using AAC; the operation construction of narrative discourse is prohibitively slow and physically exhausting, and without the experience and technological support to construct and use pragmatically, the ability and desire to extend conversation remains elusive.

An AAC system leveraging situational awareness, modern text-to-speech, and speech-to-text software, along with the capabilities of generative AI shaped by the worldview of the individual user, can facilitate a conversational communication rate that is effortless, personal, and intuitive. Effortlessness is taken to a new level by limiting the user's real-time involvement to simply choosing between three to five options rather than constructing individual words and phrases from scratch by hand, gaze, or switch-press. The user will later engage in more effortful interactions in "offline," low-pressure, and patient exchanges with the AI system to hone the system's real-time behavior.

The technology to accomplish this end is, for the most part, available right now. The remaining challenges are primarily associated with system integration and creating a model of the user that can be used to shape the system's recommendations. The field of generative AI is moving so quickly that many of these challenges may be solved or minimized without additional work from AAC vendors or researchers.

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- Heather Williams, MAT, AT/AAC Specialist
- Lyle Williams, Adaptive Technology Specialist

Resources

These links may be helpful if you would like to explore generative artificial intelligence, or the other technologies referenced in this article.

Generative AI Systems

- [ChatGPT](#) from OpenAI

- [PaLM](#) from Google
- [LLaMA](#) from Meta
- [Large Language Models](#) sit at the center of all generative AI systems
- [What is Generative AI, and how does it work?](#)
- [Large Language Models Explained](#)

Personal Worldview

- [Living Forever Through AI: Digital Immortality and the Future of Death | ENDEVR Documentary on YouTube](#) (The link begins at the start of the interview with Hossein Rahnama).
- [AI Foundation](#) is a company highlighted in the ENDEVR documentary that aims to develop digital humans with conversation generation.
- [The Primals Project](#) is a survey of primal world beliefs at the University of Pennsylvania.
- [The Big Five Personality Traits](#) try to capture the core dimensions of human personality.
- [Knowledge Graphs](#) provide a generic structure for representing an individual's opinions, experiences, and relationships.
- These links describe the process for downloading your personal data captured by [Google](#) and [Facebook](#).
- [Video on Using ChatGPT with Your Own Data](#) demonstrates an early example of how you can employ a few lines of Python code and your personal data to enhance and personalize your prompting of ChatGPT.

Spoken/Written Language and Facial Expression Processing Technologies

- [Sentiment Classification: A Beginner's Guide](#)
- [Recognizing Human Facial Expressions with Machine Learning](#)
- [Facial Micro-Expression Recognition through Machine Learning](#)

Situational Awareness Technologies

- [Google Glass](#) was first to market but doomed by the privacy concerns of others.
- [Apple Vision Pro](#) is Apple's specialized AR goggles with built-in, accurate eye tracking.
- [Apple Glasses](#) is Apple's "planned" attempt at wearable AR.

Declarations

This content is solely the responsibility of the author(s) and does not necessarily represent the official views of ATIA. No financial disclosures and no non-financial disclosures were reported by the author of this paper.

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Voices from the Field

Shared Reading with Core Vocabulary: Creating Interactive Experiences at Home

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Abstract

For individuals with significant disabilities and complex communication needs, verbal speech alone may not enable them to effectively communicate with those around them nor to access literacy. Core vocabulary provides an alternative mode of communication for students to actively participate in literacy activities, such as shared reading, at home and school. In this article, we describe a case in which a parent of a child with significant disabilities and complex communication needs learned core vocabulary and led shared reading with her daughter at home. Results indicated that not only did the child become more interactive during shared reading but that the child showed increased understanding of the purpose and meaning of core vocabulary.

Keywords: core vocabulary, shared reading, significant cognitive disabilities, complex communication needs

Shared Reading with Core Vocabulary: Creating Interactive Experiences at Home

Students with significant cognitive disabilities include those with significant limitations in intellectual functioning (i.e., IQ < 55) and adaptive behavior (Browder et al., 2020). Among those students, about 68% have complex communication needs, meaning that they are unable to communicate using speech alone (ERCL, n. d.), while about 10% use augmentative and alternative communication (AAC). Being able to communicate, verbally or with AAC, affords students with significant cognitive disabilities and complex communication needs a way to interact with others and to develop social relationships, seek and share information, engage in self-advocacy, and participate fully in all aspects of society (Beukelman & Mirenda, 2013). Additionally, communication provides these students with the ability to access academic instruction, such as literacy. However, since 25% of students with significant cognitive disabilities and complex communication needs rely on nonverbal means of communication (e.g., gestures, facial expressions) which may be misunderstood by their communication partners (Erickson & Geist, 2016; Towles-Reeves et al., 2012), accessing literacy, specifically shared reading, becomes more difficult.

Shared reading is a strategy that has been researched since the 1970s as a way to naturally integrate literacy into the education of students from all different backgrounds (Holdaway, 1982). It has since grown into a method that is used in classrooms across the country to engage students in reading. In the past 20 years or so, it has become a common, evidence-based practice to engage students with significant disabilities in literacy activities through multiple means of interaction (Hudson & Test, 2011). In 2008, a study completed by Browder and colleagues looked at how to teach elementary school students with significant disabilities to participate in shared reading activities, and its success opened the doors for additional research in literacy for individuals with significant disabilities. In fact, since then, shared reading has been used to teach students with disabilities in multiple areas of literacy. Access is a key to providing opportunities for growth in literacy for individuals with significant disabilities and complex communication needs. Browder et al. (2008) used shared reading as an intervention to promote early literacy skills in young children with significant disabilities. This showed that children will use different ways to communicate if given the opportunity.

Shared reading can also be used to increase targeted literacy skills for students with disabilities. In a study done by Mucchetti (2013), students with significant cognitive disabilities and complex communication needs showed high levels of interest in adapted literacy activities, and their overall levels of comprehension increased significantly after participation in these activities, which included variations of shared reading. The shared reading techniques allowed the students to “access age-appropriate literature and participate in dynamic, interactive language and literacy learning” (Mucchetti, 2013, p. 368). In addition, shared reading can help to increase student vocabulary and knowledge of sight words. Students can use the passages and pictures to learn vocabulary and sight words through the passages and pictures (Browder et al., 2008). Vocabulary can be specifically targeted during shared reading sessions by using directed questions to encourage students to label the vocabulary and work towards using the words in context and then making inferences using the new vocabulary (Fleury et al., 2021).

Research regarding these topics is ongoing. In 2022, there was a study completed looking at technology-enabled shared reading with students in rural areas (Cheek et al., 2022). The researchers utilized online resources and e-coaching in order to provide teachers with the training that was needed to prepare them to implement shared reading with fidelity. It went in a different direction from previous studies, as it was far less

structured and more closely followed the books themselves, rather than a scripted lesson or strict guidelines. The study found that the shared reading activities helped the students to become more engaged in literacy activities and increased their levels of communication.

Personal Statement

During the time of this project, I was a graduate student earning a master's degree in reading education. The idea for this project stemmed from an interest in reading education, particularly teaching those with significant cognitive disabilities and complex communication needs. During one course, I learned about core vocabulary, shared reading, and effective literacy practices for this population. This information was not only relevant for my future endeavors but also for my current position as a respite caregiver for a child with significant cognitive disabilities and complex communication needs, who had no formal means for formal communication. As a result, I asked my professor, the second author, to mentor me as I developed, implemented, and analyzed data for this study. The study described below is a result of their efforts.

Target Audience

Parents, teachers, therapists, and caregivers of students with significant disabilities and complex communication needs are the main audience for this project. Overall, implementing these strategies at home, school, and in the community can help increase the access for students with significant disabilities and complex communication needs to literacy. Parents can access, learn, and use these strategies at home to work towards developing an individualized communication system. Teachers can implement core vocabulary in the school environment to increase access to academic instruction. Finally, caregivers can use core vocabulary in the community to give students with significant disabilities and complex communication needs a voice.

Project Outline

Context

This was the case for Corinne, a now 14-year-old girl diagnosed with autism spectrum disorder, dwarfism, intellectual disability, and complex communication needs. As a result of her disabilities, Corinne has been enrolled in the public school system since the age of five and has spent time in a few different types of classes (i.e., moderate intellectual disabilities classroom, autism spectrum disorder classroom, and severe intellectual disability classroom). She is currently in a severe intellectual disabilities class. At the time of the project, Corinne was thirteen, and according to her mother, Carey, had never been taught to use a symbolic communication. This had been a concern for Carey and her family, as they had not been able to find anything that worked for Corinne. Corinne had some experience using a Picture Exchange Communication System (PECS), using pictures to communicate things that she wanted, but Corinne did not find it motivating, nor did it get used on a consistent basis. Corinne had utilized a total communication approach with modified sign language and physical gesturing (e.g., pointing to objects, taking the communication partner to a desired place) to communicate her wants and needs. Corinne's caregivers, teachers, and family were typically able to understand Corinne's communication without too much trouble, so the pushing for a form of systematic communication was not necessary. It was fairly easy to guess what she wanted based on her pointing and vocalizations, and, as people who knew her very well, they were able to guess the exact things she wanted.

For example, if Corinne wanted to go outside, she would grab her mother's hand and point at the door. If she wanted to watch the iPad, she would bring the iPad to an adult to unlock.

The intervention took place in Corinne's house. Corinne spends most of her time out of school at home, so this made the most sense in terms of implementation. She lived at home with her parents and three siblings, although it was her mother who completed the intervention with her. Her mother is her primary caretaker, and she is very comfortable working with her. Carey is responsible for Corinne's day-to-day needs, including taking her to school, caring for her at home, etc. Reading together is a regular part of their time spent together, so adding in the shared reading made sense during those times, either after school or before bedtime. Corinne and Carey would typically spend 10 to 15 minutes reading at a time, which was a great amount of time when implementing the interventions. They read together in various locations in their house, including Corinne's bedroom, Corinne's playroom, and the living area. These are all areas of the house that Corinne frequents, so they are comfortable areas for her.

Reading Materials

Tar Heel Reader Books

The books that were used were created through Tar Heel Reader and were created to encourage interaction with words from the core board, specifically using common words like, "go" and "like." I created five books to be used, one for each stage of the research. They included:

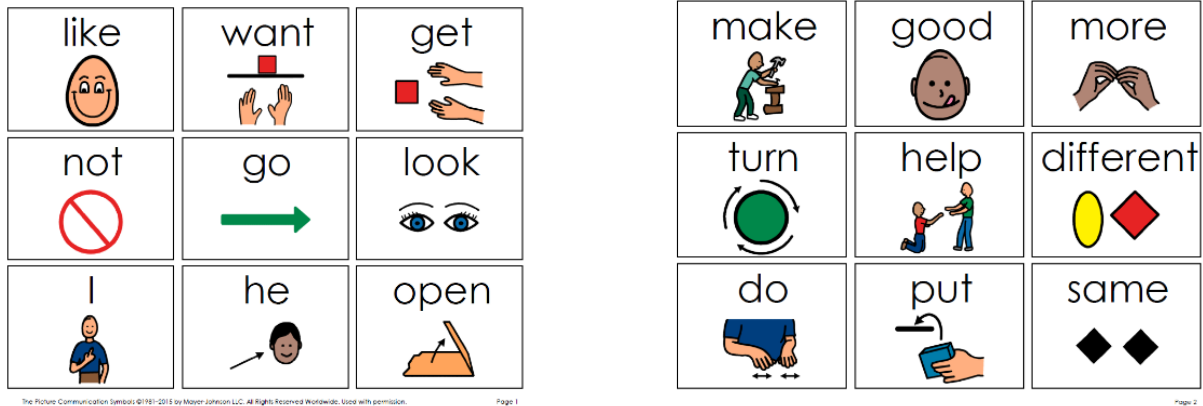
- Things Corinne Likes
- Things Piper Likes
- Let's Go to Disney World
- Let's Go on a Safari
- Let's Go to the Beach

The pictures selected for each book were real images either from the stock images on Tar Heel Reader or from me (Piper is my dog, so all pictures were provided by me). The topics were selected so Corinne could relate to them in some manner, whether in her everyday life or in things that she might have seen on TV or on her iPad.

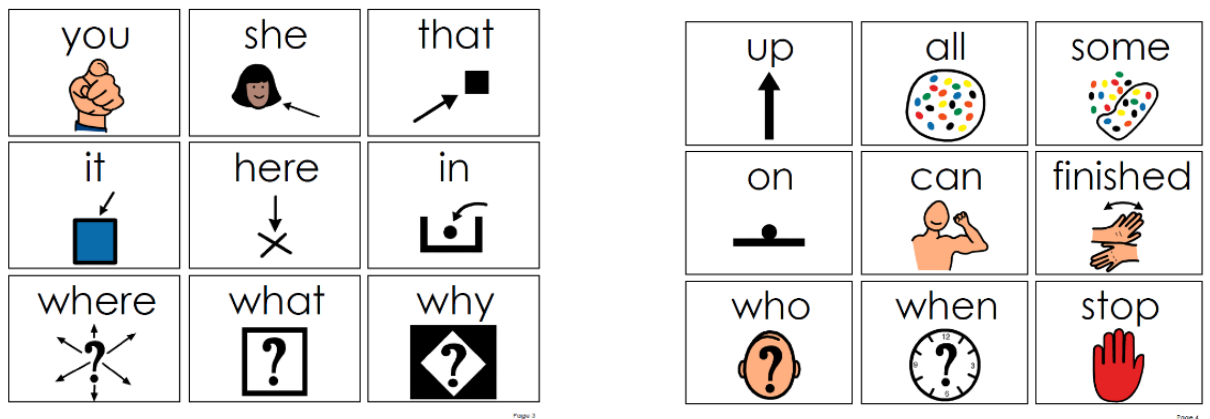
Core Vocabulary

The last piece of the puzzle was to find a core vocabulary board that would fit Corinne's needs. The board through Project Core was the perfect fit for Corinne's needs. Project Core was founded through a grant at the Center of Literacy and Disability at the University of North Carolina at Chapel Hill. The symbols needed to be large enough for her to see and select using 2 to 3 fingers (Corinne has a hard time isolating her fingers to point), but also needed to be small enough to have multiple symbols per page. I looked at Corinne's communication abilities and used the Universal Core Selection Tool on the Project Core website and ended up selecting a 3x3 board, which makes a board that is 4 pages with 9 symbols on each page. I printed out the 4-page version and the 1-page version and had Corinne test out both. Carey and I both found that Corinne responded to the 4-page core board the best as the symbols were large enough for her to point at using the motor skills that she had.

Figures 1 and 2



Figures 3 and 4



Design and Implementation

The design for the intervention was created to fit into Carey and Corrine’s busy lives. They did not have time to spend an hour or more working on the study during the week. For the baseline stage, data were taken on the interactions Carey and Corrine had reading together on a day-to-day basis. We then went into five stages, each with a different book created on Tar Heel Reader and using shared reading strategies in conjunction with the core board. Each stage consisted of multiple readings of the same book and lasted around a week. Since Carey and I were in different locations at the time, Carey and her family agreed to record the sessions so data could be taken at each stage.

The first thing that had to be done was to teach the strategy to Carey, who would implement the strategies with Corinne. I looked at online resources provided by Project Core and chose the videos that would be most useful for teaching the strategy. Both Project Core and Tar Heel Shared Reader became invaluable resources in terms of providing Carey with the instruction that was going to be required for her to use the strategy effectively. The modules from Project Core included Module 2: Universal Core Vocabulary, Module 3: Beginning Communicators, Module 4: Aided Language Input, Module 5: Supporting Individual Access to Universal Core, and Module 8: Shared Reading. In addition to the five modules from Project Core, two additional modules were selected from the Tar Heel Shared Reader website: Module 2: Follow the CAR and

Module 5: Responding and Adding More. Carey spent 2 to 3 hours over the course of a week completing the modules.

Collectively, these modules not only allowed Carey to familiarize herself with the core vocabulary board and how it is used, but they also showed her how to encourage communication using the board and how she could best prompt Corinne to communicate, and the best way to respond to her communication attempts. Carey had gone through the modules on her own and taken the quizzes; I made a weekend trip to Carey's house to provide her with materials (both books and core boards) and to do an in-person instructional session where Carey could practice and ask questions if she needed to. We spent around an hour going over different methods and ideas that would help her to do it in a way that would be effective for Corinne. In addition, I modeled for Carey how I would make comments on a story. I also sat down with Carey and the first book to create some notes for potential comments that could be made for each page so that there would be less stress trying to figure out comments on the spot. The goal was that commenting on each page would become a more natural process as Carey got used to the format and started to understand how to respond to Corinne. After the instructional session, Carey modeled how she would make comments and read the book and expressed that she felt comfortable moving forward. Throughout the study, Carey would send me videos and ask me questions on how she could improve what she was doing. We typically communicated via text message 2 to 3 times a week.

One way to encourage communication during shared reading is to follow the CAR, which stands for Comment, Ask, Respond (Erickson & Koppenhaver, 2020). When using the CAR strategy, the reader leads with a **Comment** such as "I **LIKE** watching TV." Then they **Ask** for participation, sometimes with a question ("Do you **LIKE** watching TV?") and **Respond** by adding a little more ("Let's **GO** watch TV after we're done reading!")

In this intervention, asking a question was removed from the method. The goal was to get Corinne to make a comment in response to her mother's comment. For Corinne, that was best achieved by simplifying the process, by just having Carey make a comment and wait for a response. Some of the books did not lend themselves to asking questions, and after asking her a few questions, we found that Corinne responded more readily to comments as opposed to answering questions. If no response was given within the first wait time, she would make her comment again and then wait. At that point, Corinne either made a response, or Carey moved on to the next page. This ensured that an appropriate pace was kept and that we were never forcing communication, only giving her the opportunity to communicate.

Measuring Implementation

After some consideration, I decided to use two different measures. The first measure was the Adult Child Interactive Reading Inventory (ACIRI), which is a rating system that rates both the adult and child on the following measures: (a) enhancing attention to text, (b) promoting interactive reading and supporting oral language, and (c) using shared reading strategies.

As Corinne is not verbal, it was changed to measure how Corinne was communicating with the core board. I specifically looked at how Carey was following the shared reading strategies that she learned about and how Corinne was interacting with both the core board and her mom. The ratings are done on a scale of 3–1, 3 being the most and 1 being the least.

The second form of data that was used was frequency data that measured a few different things in terms of how Corinne responded to communication attempts. First, the attempt would be determined to be intentional or unintentional. These were defined by the following:

- Unintentional: Anytime Corinne would slam her whole hand on the board, pick it up to try to throw the board, randomly select a word without looking, etc.
- Intentional: Anytime Corinne looked at the board and chose a single word. If an attempt was determined to be intentional, it would then be counted as either copying or initiation, defined as the following:
 - Intentional Copying: If Corinne copied what her mom commented (i.e., Mom touches “like” and Corinne also touches “like”);
 - Intentional Initiation: If Corinne decided to either start the conversation about each page on her own or if she responded to her mother with an original thought.

I anticipated that once Corinne started making intentional comments that she would start by copying what her mother said and then move into more initiation as she became more confident with using the board.

Outcomes and Benefits

Outcomes

Just a few days into the first round, the understanding and appropriate use of the core board increased significantly. Corinne started out by modeling her mom, which is fairly similar to how speech develops in children. By the third day, her intentional communication outweighed her nonintentional communication and her initiation of communication skyrocketed almost immediately, going from no intentional attempts on the first day to nine intentional attempts on the fifth day (see figure 5). The intentional communication continued to grow up to a peak of 50 intentional communication attempts (see figure 6) and 23 initiated communication attempts (see figure 10) in a single session around the end of the second stage and through the middle of the third stage of the research. In December, the intervention paused when Corinne became sick. Since Corinne is immunocompromised, when she becomes sick, she can be sick for weeks at a time. Once Corinne was healed, Carey then became ill. This series of illnesses seriously impacted their ability to continue with their sessions. As a result, the intervention paused for about two months and extended beyond the initial frame.

When teaching someone with significant disabilities how to do something new, it typically requires consistent teaching and practice for a while until the skill is mastered (see Browder et al., 2020). Corinne was successful in the beginning of the intervention; however, taking a break for illness ultimately put the research on hold. As a result, the basis of the research changed because it felt like we were starting from the beginning. The questions then became: How much did Corinne retain during the two-month research pause? Would she lose all gains in comprehension and have to rebuild her knowledge, or would her rate of growth be expedited because she had already learned how to do it before? How much would she remember after two months of little to no use?

Once the study began again, there was a period of time where Corinne had little interaction with the core board, both intentionally and unintentionally. After a few days, however, Carey started to notice the intentional use quickly with very few unintentional contacts with the board (see figures 7 and 8). The biggest shift in her use before the break and the use after was the amount of communication. There were fewer communication attempts overall after the break (see figures 7 and 8), and I can only hypothesize why. There is the possibility

that she had less desire to communicate based on the books that were being read or that her desire to communicate had gone down at that time.

Figure 5

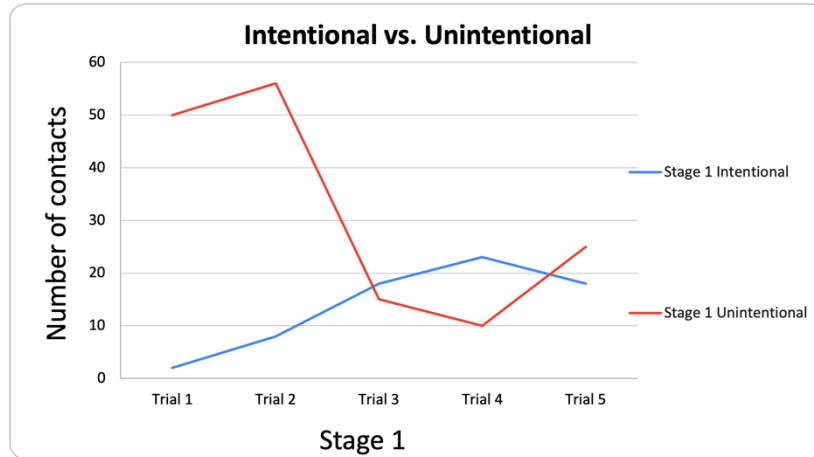


Figure 6

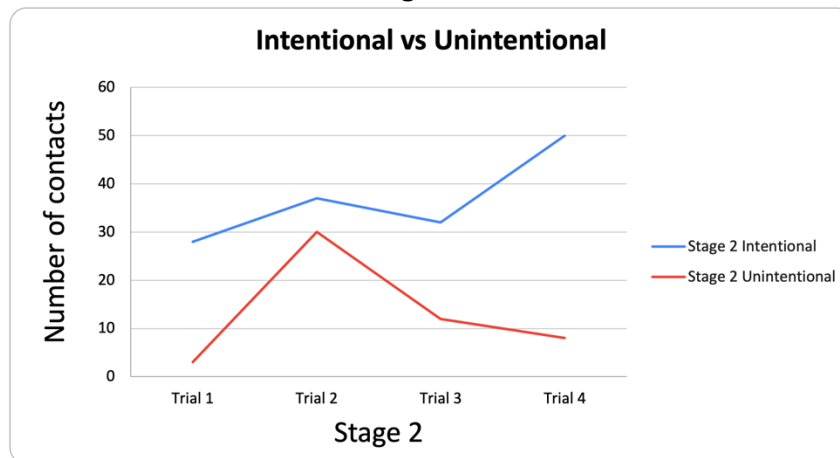


Figure 7

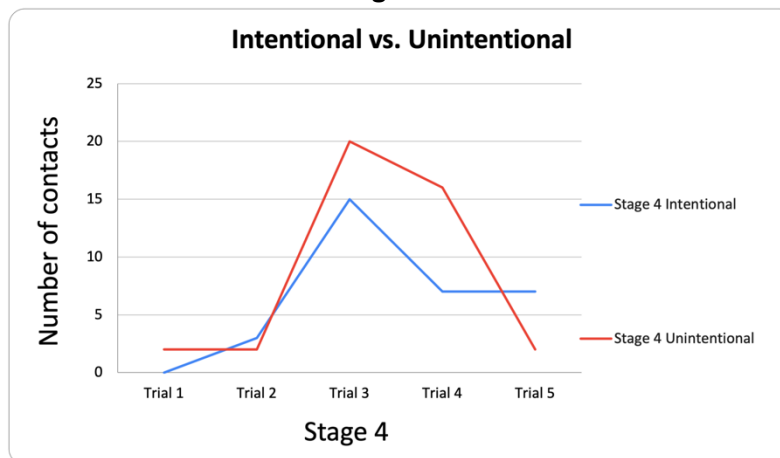


Figure 8

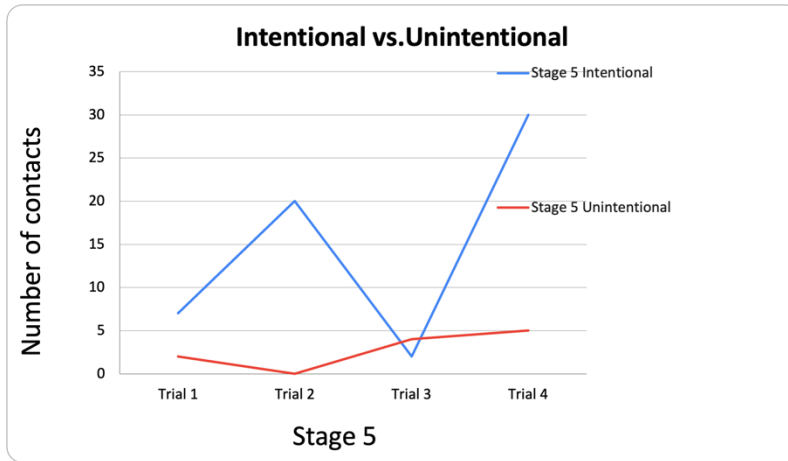


Figure 9

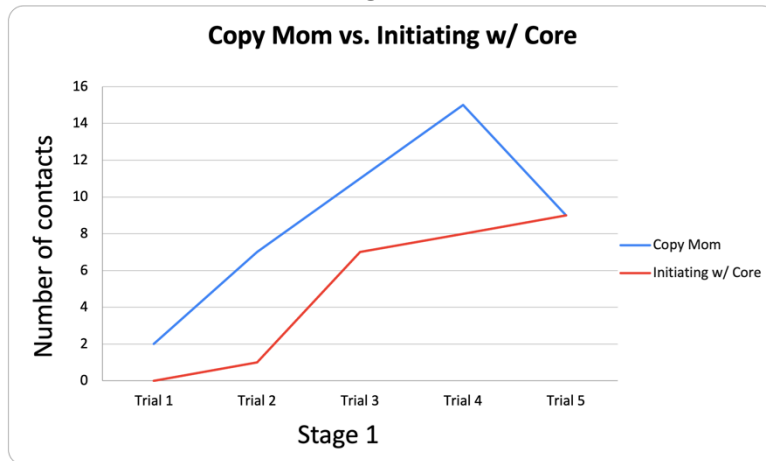


Figure 10

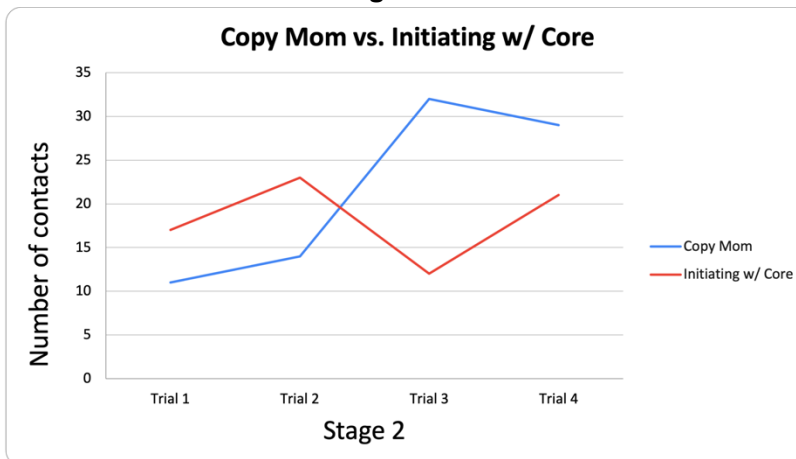
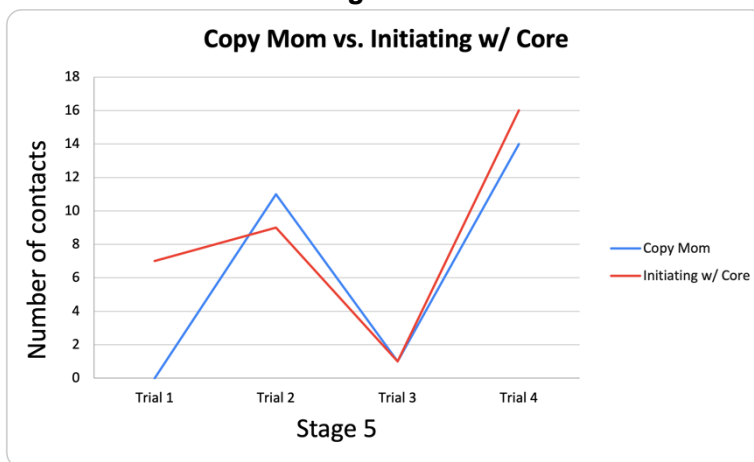


Figure 11

Benefits

Based on the results from this study, there are a few positive implications that feed into the area of study. When I started on this project, I wanted to see if there was a way that parents could independently teach their children how to systematically communicate. Having watched Corinne grow up through late elementary and middle school, I felt like there had to be something that could be done to help her communicate effectively if those skills were not being taught while she was in school. Upon learning about shared reading and how easy it can be to implement once taught, I saw the opportunity to not only help Corinne and her family, but also a way to potentially help other families that are in the same situation. As a high school teacher now, I can see even more clearly how students can fall through the gaps and get to their late teens without a way to communicate. As children get older, education starts to focus on other things, like vocational skills, that may prevent the larger focus on communication. This is largely due to the fact that when a child turns 16, a transition plan, per IDEA (Individuals with Disabilities Education Act, 2023), is created to help increase postsecondary outcomes for individuals with disabilities (Cannella-Malone & Schaefer, 2015). When this transition plan is made, IEP goals and the student's education can shift away from communication and academics and towards meeting these transition goals. This experience indicates that even with only 10 to 15 minutes a day, a child can gain systematic communication skills.

Perhaps one of the most noteworthy benefits of this project was that Corinne was able to maintain her communication skills, and her mom continued to implement shared reading with the core vocabulary board, after a break. Generalization and maintenance can be difficult for individuals with significant disabilities, as skills can often be forgotten. However, Corinne maintained the skill over the course of a month off. This is very promising for individuals and families hoping to increase the communication opportunities for individuals with disabilities. What it shows, at least in this case, was that the implementation does not have to be perfect for it to be successful. In a family setting, daily activities like this can be hard to get done, and results of this study indicate that consistency outweighs perfection.

Over a year after the study ended, core vocabulary is something that Corinne uses on a daily basis, both in school and at home to communicate with her teachers, caretakers, parents, and siblings. Although most often used at mealtimes, she uses core vocabulary across a variety of contexts in the school setting, including while completing schoolwork. She is also being evaluated for a communication device—something that had been unattainable for her prior to participating in the study. Clinicians before this found that she was not interacting

with picture symbols to communicate sufficiently enough to be considered for a device. Carey has also mentioned how many opportunities open up for Corrine because of her communication and how necessary it has become for her. It has allowed Corrine to become more independent and to express exactly what she wants without any guessing.

Challenges

This study was not without its limitations. The biggest limitation was the “human factor” in a sense—how things happen in everyday life that prevent people from following through with what they plan. There were things that happened during the study that could not have been anticipated, like Carey getting sick with mono and having to take a large break in the middle of the study to get better. A huge takeaway, however, was that Corinne maintained the skill and was able to continue even with the extended break. In the time since the study, Corinne has generalized her use of the core board into both academic and daily living activities, which has allowed her to communicate more with different people around her.

As for limitations in the implementation for other families, the biggest one would be time. The resources that were used to create everything for the study were free, which means that it can be accessible for all sorts of families. However, the training took 2 to 3 hours overall across a week and, for consistent implementation, it was 10 to 15 minutes a day spent reading and working with the core board. It worked in Carey and Corinne’s favor because reading together was already a part of their day, but for individuals that might not be as inclined to sit and listen to reading, it might not be as successful as it was for them.

Discussion

Communication is a skill that should be accessed by all. For many families of individuals with significant disabilities, formal communication is something that can be difficult to obtain. Once individuals reach higher levels of school, the focus on formal communication can lessen in order to make room for other topics like life and vocational skills. The push for employment for individuals with disabilities has been prevalent recently. For example, Employment First is a national movement that recognizes that all citizens, including individuals with significant disabilities, are capable of full participation in integrated employment and community life (*Employment First* | NC Office of Human Resources, n.d.). The initiative has been enacted in 40 states so far, and it helps individuals with significant disabilities find government jobs that pay real wages. That, in conjunction with the IDEA, has moved the trend for higher level special education towards vocational skills. For parents of individuals with significant disabilities, there is not much information that is shared about how they can help their child or young adult with communication as they age. This study showed that parents have the ability to do this with materials that they can access freely and easily. Using resources like Project Core and Tar Heel Reader allow a parent to not only access the materials needed to teach their child, but also provide instructional material for parents to learn how to do it themselves at home.

When parents are able to take the time to do shared reading at home with their children, it shows very promising results for the individuals eventually. The communication skills learned through shared reading can be generalized not only into the classroom, but into other facets of their lives. Having formal communication allows them to communicate with both familiar and unfamiliar people across settings. Nonverbal and non-traditional communication is especially useful for individuals in a familiar setting with familiar people, but often does not translate to those outside of their familiar circle. Core vocabulary gives individuals an opportunity to communicate with those they wish to without intervention from others if they choose to.

Although these results are preliminary, they are promising in terms of the maintenance shown by Corinne. Maintaining skills is often a concern for parents and teachers of individuals with disabilities because losing skills is a common occurrence. When there was a month-long break in the study, it was assumed that Corinne would lose the skills that she had gained from the first half of the study. However, Corinne was able to pick back up where she left off after only a session or two, which meant that Corinne was remembering what she was learning. For families, this means that the pressure to consistently do the strategies and practice decreases. Individuals with disabilities can still benefit from shared reading and communication practice even if it is not perfectly consistent. This means that more families can work with their children, siblings, or other family members towards formal, functional communication.

Declarations

This content is solely the responsibility of the author(s) and does not necessarily represent the official views of ATIA. No financial disclosures and no non-financial disclosures were reported by the author(s) of this paper.

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Voices from the Field

Quality Indicators for Assistive Technology: How an Idea Grew

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Abstract

The Quality Indicators for Assistive Technology (QIAT) have played a critical role in the development and delivery of effective services for children with disabilities for the past 25 years. The idea for quality indicators was grassroots in origin and began in the 1990s. It grew through the involvement of hundreds of assistive technology (AT) service providers across the country. QIAT provided a way for individuals, teams, and agencies to analyze and improve their AT services. A range of tools to support the understanding and use of the quality indicators has been developed.

Keywords: quality indicators for assistive technology, QIAT, assistive technology services, service providers

Quality Indicators for Assistive Technology: How an Idea Grew

From the first modified keyboard to the full array of incredible assistive technology (AT) tools available today, the AT industry has led a charge to support individuals with all varieties of challenges, providing more and more technology-based solutions for those with disabilities. For teachers and other school-based professionals in schools, the challenge has been to match those tools to the specific tasks and overall needs of each student. As the scope and variety of AT has evolved, so has the complexity of selecting tools and implementing AT programs to support students to complete critical tasks in their environments and make progress in their curricula. When the match does not prove successful, it is seldom the fault of the technology. Much more frequently, the problems that occur are related to the process of selection and matching of that technology to the abilities of the student who will be using it and what they need to accomplish. The Quality Indicators for Assistive Technology (QIAT) grew out of a need to help and support those individuals in the schools who are engaged in providing the critical AT services of selecting, implementing, and monitoring AT.

AT tools are often developed because of a single idea. An idea like, “Maybe there is a way to make a task simpler or easier, or even a way to go around a problematic step.” In the children’s book, *What Do You Do with an Idea?* (Yamada, 2013), the young narrator has an idea, and, with that idea have come many questions. Questions such as, “Where does an idea come from? What do you do with an idea? How do you grow an idea?” Those questions accompany many new concepts and can lead to a successful outcome. They provide an intriguing framework for looking at the development and success of the QIAT.

Where Did the Idea for QIAT Come From?

The idea for QIAT started with the thought that the individuals who were in the field and supporting students who use AT could describe effective and efficient services in a way that would lead to widespread systematic and consistent services. The idea was grassroots in its origin, coming from practitioners in the field. Initial conversations were casual and happenstance around topics of how to assess need for AT within the mandated timelines, where to find products, how to pay for them, etc. These initial conversations occurred at conferences, in school districts, at clinics, wherever service providers gathered. They often focused on a shared frustration with current practice that was both haphazard and inconsistent. Tool-based rather than student-focused approaches were common.

In addition to the definition of AT devices, the Individuals with Disabilities Education Act (IDEA; 1990) included a list of AT services. Those services include: [\(a\) the evaluation of the AT needs of a child](#); [\(b\) purchasing, leasing, or otherwise providing for the acquisition of assistive technology devices](#); [\(c\) selecting, adapting, maintaining, repairing, or replacing assistive technology devices](#); [\(d\) coordinating and using other therapies, interventions, or services](#); [\(e\) training or technical assistance for the child or family](#); and [\(f\) training or technical assistance for professionals](#). The list of services helped to clarify the kinds of actions that must be taken to address the regulations. The services were listed but not further defined in statute, leaving states and public agencies the freedom to define their own ways of doing things. While there was agreement that there were many ways to do it right, there was no consensus regarding what “right” looked like across settings.

After the requirement to provide AT devices and services became part of IDEA, there was confusion and questioning of what “provide” meant, who would make those critical decisions, and how a school district could develop and manage AT services. Then the additional requirement in IDEA (1997) to “consider” the need for

AT for every student with an Individualized Family Service Plan (IFSP) or Individualized Education Program (IEP) generated even more questions.

Across the country, professionals working with students with disabilities struggled to develop and provide AT services that were of consistently high quality. That struggle was complicated by the complexity of issues related to AT, the need for input from a variety of professional perspectives, and a lack of guidance (Bowser & Reed, 1995; Chambers, 1997; Zabala & Carl, 2005). Research confirmed those issues and identified specific barriers to developing the needed guidance (Hutinger et al., 1996; MacGregor & Pachuski, 1996; Todis, 1996; Todis & Walker, 1993).

In a qualitative study of 13 students using AT, Todis and Walker (1993) found that AT was underutilized and often not used to address the educational goals for which it was intended. They reported that a lack of communication between service providers and a lack of understanding of the complex issues related to AT were the primary barriers to effective AT use. Todis (1996), reporting on the same study, concluded that the complexity of issues around AT use often made it difficult to reach consensus. She called for a greater focus on the processes used to make AT decisions.

In their study of experienced AT service providers, MacGregor and Pachuski (1996) concluded that there was a need for interdisciplinary teams to work more effectively together to develop carefully considered programs. Hutinger, Johanson, and Stoneburner (1996) found a lack of alignment of goals and a lack of collaboration to be significant problems in their long-term case study. They called for increases in collaborative planning, proactive support from administrators, and a clearly defined system of policies and procedures. Each of these studies provides a glimpse into the struggles that the educational teams were facing.

Other factors were instrumental in confirming the need for development of quality indicators. Consideration of the need for AT, a process required in IDEA (1997), was not defined in law. Similarly, AT assessment could mean a variety of activities, from a simple trial period conducted by classroom staff to a consultation from an individual with AT expertise, or a formal assessment by a team including educators, family members, and individuals from a variety of disciplines (e.g., occupational therapists, physical therapists, speech language pathologists). Implementation and delivery of AT services is not addressed in IDEA except as it relates to periodic review of the IEP. These and other factors pointed to the need for clearer descriptions of high-quality AT services, regardless of the service model.

Target Audience and Relevance

The information in this article is useful to all individuals who work with students with disabilities, including families, and is helpful in training others to work with them. It is also useful for developing policies and procedures. It may be most critical for those who serve on teams making decisions about AT (e.g., IFSP teams, IEP teams, AT teams, or transition teams, including administrators and families of students with disabilities). The work is of value to educators and related service providers who need it to evaluate and improve the quality and consistency of the AT services they provide. Families use QIAT to gain a picture of appropriate AT services in schools and their own role in creating them, from selection to effective use. Universities use the quality indicators in developing awareness, understanding, and competency in future educators. Policy makers use the information in developing judicious policies and procedures.

What Do You Do with an Idea? Development and Dissemination of QIAT

In late 1997, two AT practitioners, Jane Korsten and Joy Zabala, ended up in a long car ride where the conversation focused on the idea that the professionals who provided AT services needed to define how those services would look. That original discussion led to many more between Korsten and Zabala and began to include several of their colleagues as they met at training sessions and conferences. The dialog around the meaning of AT consideration was increasing at these professional gatherings due to the new provision in IDEA that the need for AT devices and services must be considered at each IEP meeting. In too many cases, consideration of the need for AT was simply not happening in a meaningful way because of the confusion about what it meant and the lack of specific directions about how to do it effectively.

As a result, in early 1998, Korsten and Zabala finalized a plan to invite 14 colleagues, each with a different perspective on AT, together for a three-day retreat in June 1998 to explore how to tackle this need. Day one was marked by a diverse and intense exchange of ideas around the complexity of issues and processes related to AT use, AT training, and delivery of AT services. The realization that everyone was talking about the same things from different professional perspectives and using different vocabulary based on their disciplines and service delivery models, fostered trust and a willingness to work together. Four areas of common concern were identified. They were: considering the need for AT, assessing the need for AT, documenting AT on the IEP, and implementing the use of AT.

Because so many teams across the country were struggling with considering the need for AT, it was decided to begin by describing the characteristics of an effective consideration process. Looking for a way to talk about and write this description, those present at the three-day retreat turned to *The Program Evaluation Standards 2nd edition* (The Joint Committee on Standards for Educational Evaluation, 1994) as a model. The model included an overview, guidelines, common errors, and illustrative cases for each area of concern. The model provided structure and guided the creation of initial descriptions of high-quality AT services.

As this small group considered what to do with their idea, they decided to present at the Closing the Gap Conference (October 1999). More than 300 individuals attended that session. The presentation focused on the descriptors of effective AT consideration in the IEP meeting. It soon became very clear that many present disagreed with the use of the term “standards” because of the focus on standards-based education at that time. Discussion shifted to how to describe quality without using the term “standards.” Use of the term “quality indicators” grew out of that discussion. The focus shifted to identifying the common elements of quality service with likelihood of best outcomes, regardless of service delivery model. Based on very early input from session participants, the name of the work was changed from *standards* to *quality indicators*.

The big idea that eventually became QIAT had come into being, but a way to grow that idea had yet to be developed. During the evolution of developmental work, participants identified eight key areas. The current set of Quality Indicators for Assistive Technology Services (QIAT) addresses the areas of Consideration of the need for AT; Assessment of the need for AT; Inclusion of AT in the IEP; Implementation of AT; Evaluation of the Effectiveness of AT use; Transitions that include AT; Administrative support for AT; and Professional Development for AT.

How Do You Grow and Idea?

Project work focused first on development of descriptions of high-quality AT services (quality indicators) and later, on self-evaluation matrices for each area. These two resources describe the significant factors that ensure that the supports and services that are provided to people who use AT are of a high quality and focused on increasing their function and independence. The indicators provide a description of what quality services look like. The matrices are based on the idea that change does not happen immediately, but rather, moves toward the ideal in a series of steps. They are used as a rubric with variations that describe in operational terms what practice might look like in the classroom.

With the participation of thousands of other individuals through conferences, presentations, summit meetings, and an electronic mailing list, the body of work began to emerge. The large amount of information collected was edited, aligned, and presented in a way that is easily used and available to professionals and families.

Dissemination of the QIAT began immediately after the initial drafts were developed. Dissemination activities revealed additional needs for clarity in descriptions of high-quality AT services. It became apparent that there was no common agreement about definitions that were frequently used in describing AT services. Even the word “team” held different meanings in the variety of approaches to provision of AT services. In some cases, a team might indicate a group of educators and related service providers who were highly knowledgeable about AT, while in other service models, the team referred to the group of individuals who developed a student’s IEP. During dissemination activities, it was not uncommon for at least one person to declare, “I AM the AT team” referring to their role as an AT expert.

For the QIAT work to be valuable in a range of settings, participation in the continuing development was required from people with a wide range of perspectives on AT. Following the first presentation in 1999, the Leadership Team developed a system for gathering input from groups of participants that would facilitate participation from large numbers of people representing many disciplines and many areas of the country.

The system included asking participants to react to core ideas and to write ideas on colored index cards. Each person completed one card for each section of the area that was being addressed. For example, in the case of the indicators for the area of Inclusion of AT in the IEP, a facilitator described the quality indicator. Participants were given a chance to ask clarifying questions about the content, but wrote their edits, comments, and answers to the guiding questions on the index cards.

Event participants were also asked to address any, or all, of the following three questions:

1. Is there a need for this information (i.e., Is it important to include)?
2. Do you have suggested edits or wording changes for this specific indicator?
3. Is there anything that is missing?

This process was used to develop and edit the quality indicators and the common errors at a series of conferences and QIAT summits (See Table 1). It helped to ensure that all participants’ input was collected regardless of the size of the audience or the length of the presentation.

Use of the comment card process ensured that the Leadership Team had full information from participants, and leaders were able to sort the cards in a variety of ways to help inform the writing. A summary was provided

to the original participants, when time allowed, of the changes that had been made by the Leadership Team as a result of the group work.

Table 1: National Meetings – QIAT Summits

Year	Location	Focus	Products	Participants
1999	Kansas	Organizational meeting		Leadership team (LT)
2000	Missouri	Organizational meeting	Basic Indicator Areas	LT and Invited Group
2001	Missouri	Self-assessment for all 8 indicator areas	Self-assessment drafts all Indicator areas, Paradigm for self-assessment rating scale developed	Open Summit-(all members of QIAT list invited)
2002	Oregon	Transition and AT Professional Development	Intent statements, Common errors, Self-assessment matrix	LT and Invited group
2003	Oregon	Transition and AT Professional Development	Resource document development	Open Summit
2004	Georgia	Transition and PD	Self-assessment matrix/annotated resources list	LT and Invited group
2005	Georgia	All areas	Resource documents for remaining areas	Open summit
2006	Texas	Evaluation of Effectiveness and Implementation	Guiding documents	LT and Invited Group
2007	Texas	IEP, Imp, E of E, PD and Parents	Focus on products for each area, Illustrative stories about use of QIs	Open Summit
2008	Minnesota	Implementation/Evaluation of Effectiveness	Guiding documents, 2 stories (high incidence disability and low incidence disability)	LT and Invited group
2009	Minnesota	Transition, Professional Development, QIAT-PS	Guiding Documents, illustrative stories QIAT-PS development	Open Summit Included QIAT-PS Group
2010	Florida	Administrative Support, Consideration/ QIAT-PS Many Roles Many Voices	Guiding Documents Development of QIAT PS Many roles descriptions	Open Summit
2011	Arkansas	Assessment/ Transition/ QIAT PS	Guiding Documents and stories Development of QIAT PS continues	Open Summit

Input, Dissemination, and Public Response

To augment individual sharing by members of the Leadership Team, four primary strategies were used to invite and engage participation. Strategies included extended gatherings through QIAT Summits, interactive conference presentations, QIAT website and listserv, and publications in consumer and research journals.

QIAT Summits

QIAT Summits were face-to-face work sessions that took place in a variety of states and were sponsored by state-level AT programs. The Summits provided a way to expand the number of people who participated in the actual development and writing of the Quality Indicators. Anyone interested in AT services was invited to attend. Most participants were also active in discussions on the QIAT electronic list, and many had attended QIAT sessions at conferences. Summit participants were representative of all groups identified as potential consumers of QIAT work, including consumers, service providers, families, administrators, higher education professionals, and policy makers. Table 1 lists the summits, their dates, and locations. They were held in different areas of the United States so that individuals from across the country could participate.

During QIAT Summits, participants worked collaboratively in large and small groups to:

1. Deepen understanding of the purpose, scope, and potential uses of the quality indicators,
2. Review quality indicators to determine changes needed, if any, to move toward comprehensive coverage,
3. Revise, refine, and expand upon the quality indicators, through collegial conversation and conference feedback, and
4. Discuss, develop, or plan for tools that could assist with implementation of the quality indicators.

Interactive Conference Presentations

Another of the primary means of sharing and expanding the original work was through interactive sessions at local, state, national, and international conferences. More than 3000 participants in such sessions were offered the opportunity to provide formative evaluation data that would be used during continuing development and to become actively involved in QIAT development activities.

During these interactive sessions, participants engaged in critical discussion of the work and provided oral and written input into the continuing development process. Though the written input was open-ended, three questions were used to shape responses:

1. Is there a need for quality indicators?
2. How would you use the quality indicators in your setting?
3. How would you modify the existing indicators?

Throughout the development of QIAT, the thoughts and ideas gained from participants at conference sessions served as formative evaluation data that informed the revision and continued development of QIAT. In addition, those data also helped determine the perceived value of QIAT to people who attended each session. Based on more than 3000 written responses and many hours of collegial conversation, it was determined that QIAT could provide useful information to those concerned with the development and delivery of quality AT services.

QIAT Website and Electronic Mail List

Initially, the QIAT website, hosted by the University of Kentucky and located at QIAT.org, contained drafts of the QIAT indicators, a historical perspective on the work, upcoming participation opportunities, and an invitation to join the QIAT list. As QIAT work progressed, the QIAT website was expanded to include copies of the quality indicators in various stages of development, searchable archives of all messages sent through the QIAT List, detailed information about the QIAT Summits, a section for research related to the QIAT work, and links to complementary resources suggested by QIAT participants.

The QIAT List was developed to facilitate widespread engagement in collegial conversation about the indicators and topics related to their continued development. List discussions evolved to focus not only on QIAT, but also on a range of topics that pertain to high quality AT services, such as report writing, research, staff qualifications and certification, device specifics, and state standards. As of October 2023, there are more than 5,000 participants.

Wojcik (2015) has pointed out that the QIAT List serves as an online community of practice (CoP) allowing members to engage in discussions regarding AT service delivery, and that online communities have a role in the development of knowledge and skills related to the field. Online CoPs, such as the QIAT List, provide opportunities for members to engage in conversations about the practices of their field and, through discussion, improve on those practices. Takahashi (2011) found that teachers engaging in CoPs work together to co-construct their efficacy beliefs regarding their shared practices.

CoPs provide opportunities for members to share knowledge, test ideas, and, through discussion, generate new knowledge. Members of the QIAT List engage in conversations that confirm practices that have been found to be effective, modify knowledge about practices in the context of new issues and problems, and generate new solutions for new issues that arise. Participation in the list helps new members develop an understanding for AT service delivery and helps deepen the understanding of AT service delivery of more experienced members (Wojcik, 2011).

Publications

Early publications in special education journals and textbooks described the basic principles and structure of the quality indicators and why they were needed (Bowser et al., 1999; Zabala et al., 2000, Zabala & Carl, 2005). They also explained the underlying principles that were always expected and did not need to be explicitly restated in each indicator. These included (a) the requirement that all AT services developed and delivered by education agencies must follow the legal mandates of federal and state laws; (b) that AT efforts at all stages involve ongoing collaboration by teams that include families and caregivers, school personnel, and individuals from other agencies as appropriate; and (c) that all team members are expected to follow the code of ethics for their respective professions. These early publications helped explain the quality indicators and led to a growing interest and understanding.

Refinement of the Idea

Each opportunity for public input also provided the Leadership Team with thoughts and ideas about additional components that could be added to the QIAT “suite” of tools to enhance the usefulness of the indicators and expand the public knowledge base.

- **Quality Indicators** are one- or two-sentence descriptions of an essential element of an AT area. They form the basis of all QIAT work (See below).
- **Self-evaluation Matrix** documents are available for each of the eight indicator areas (QIAT.org). They use an innovation configuration matrix approach (Hall & Hord, 1987) which describes variations which are rated 1–5 with 5 being excellent.
- **Common Errors** are identified for each of the eight indicator areas. The list of common errors generally includes five to seven errors which, when made by IEP teams, affect the quality of the AT service.
- **Intent Statements** are developed for every indicator in every area. They offer a paragraph that expands and clarifies the idea presented in the indicator itself.
- **Illustrative Examples** are stories that are included in the QIAT publications and guiding documents. Each example describes the practical application of the ideas embodied in the indicator and intent statement.
- **Guiding Documents** operationalize the indicators of quality to assist educational agencies and other professionals in providing appropriate devices and services to students with special needs. Guiding documents are several pages long and offer a more comprehensive description than the indicators and intent statements.
- **Planning Documents** include forms and checklists related to each indicator area. They are intended to help IEP teams as they work with the indicators in planning an individual student’s program.
- **Annotated Resource Lists** are provided for each of the eight indicator areas. The resources listed are more detailed and longer than those resources developed by the QIAT project and can be used to augment the understanding of a specific area.
- **QIAT Publications** are the culmination of the development of this range of tools. They are *Quality Indicators for Assistive Technology: A Comprehensive Guide to Assistive Technology Services* (2015), *Leading the Way to Excellence in AT Services* (2018), and *The QIAT Companion: A Just In Time Resource for Implementing the Quality Indicators for Assistive Technology* (2020). The books have provided another resource for AT service providers and family members to learn about and apply the content of QIAT.

QUALITY INDICATORS

Consideration of AT Needs

1. Assistive technology devices and services are **considered for all students with disabilities** regardless of type or severity of disability.
2. During the development of an individualized educational program, every IEP team consistently uses a **collaborative decision-making process** that supports systematic consideration of each student’s possible need for assistive technology devices and services.
3. IEP team members have the **collective knowledge and skills** needed to make informed assistive technology decisions and seek assistance when needed.
4. Decisions regarding the need for assistive technology devices and services **are based on the student’s IEP goals and objectives, access to curricular and extracurricular activities, and progress in the general education curriculum.**
5. The IEP team **gathers and analyzes** data about the student, customary environments, educational goals, and tasks when considering a student’s need for assistive technology devices and services.

6. When assistive technology is needed, the IEP team **explores a range of assistive technology devices**, services, and other supports that address identified needs.
7. The assistive technology consideration process and **results are documented in the IEP** and include a rationale for the decision and supporting evidence.

Assessment of AT Needs

1. **Procedures** for all aspects of assistive technology assessment are clearly defined and consistently applied.
2. Assistive technology assessments are conducted by a **team with the collective knowledge and skills** needed to determine possible assistive technology solutions that address the needs and abilities of the student, demands of the customary environments, educational goals, and related activities.
3. All assistive technology assessments include a functional assessment in the student's **customary environments**, such as the classroom, lunchroom, playground, home, community setting, or workplace.
4. Assistive technology assessments, including needed trials, are completed within **reasonable timelines**.
5. Recommendations from assistive technology assessments are **based on data** about the student, environments, and tasks.
6. The assessment provides the IEP team with clearly **documented recommendations** that guide decisions about the selection, acquisition, and use of assistive technology devices and services.
7. Assistive technology needs are **reassessed** any time changes in the student, the environments and/or the tasks result in the student's needs not being met with current devices and/or services.

Documentation in the IEP

1. The education agency has **guidelines for documenting** assistive technology needs in the IEP and requires their consistent application.
2. All **services** that the IEP team determines are needed to support the selection, acquisition, and use of assistive technology devices are designated in the IEP.
3. The IEP illustrates that assistive technology is **a tool to support achievement of goals** and progress in the general curriculum by establishing a clear relationship between student needs, assistive technology devices and services, and the student's goals and objectives.
4. IEP content regarding assistive technology use is written in language that describes how assistive technology contributes to achievement of **measurable and observable outcomes**.
5. Assistive technology is included in the IEP in a manner that provides a **clear and complete description** of the devices and services to be provided and used to address student needs and achieve expected results.

AT Implementation

1. Assistive technology implementation proceeds according to a **collaboratively developed plan**.
2. Assistive technology is **integrated** into the curriculum and daily activities of the student across environments.
3. Persons supporting the student across all environments in which the assistive technology is expected to be used **share responsibility** for implementation of the plan.

4. Persons supporting the student provide opportunities for the student to use a **variety of strategies—including assistive technology** and to learn which strategies are most effective for particular circumstances and tasks.
5. **Learning opportunities** for the student, family and staff are an integral part of implementation.
6. Assistive technology implementation is initially based on assessment **data** and is adjusted based on performance data.
7. Assistive technology implementation includes **management and maintenance of equipment** and materials.

Evaluation of Effectiveness

1. Team members share **clearly defined responsibilities** to ensure that data are collected, evaluated, and interpreted by capable and credible team members.
2. Data are collected on specific student achievement that has been identified by the team and is **related to one or more goals**.
3. Evaluation of effectiveness includes the **quantitative and qualitative measurement of changes** in the student's performance and achievement.
4. Effectiveness is evaluated **across environments** during naturally occurring and structured activities.
5. Data are collected to provide teams with a means for **analyzing student achievement and identifying supports and barriers** that influence assistive technology use to determine what changes, if any, are needed.
6. **Changes are made** in the student's assistive technology services and educational program when evaluation data indicate that such changes are needed to improve student achievement.
7. Evaluation of effectiveness is a dynamic, responsive, **ongoing process** that is reviewed periodically.

Assistive Technology Transition

1. **Transition plans address assistive technology needs** of the student, including roles and training needs of team members, subsequent steps in assistive technology use, and follow-up after transition takes place.
2. Transition **planning empowers the student** using assistive technology to **participate** in the transition planning at a level appropriate to age and ability.
3. **Advocacy related to assistive technology use is recognized as critical** and planned for by the teams involved in transition.
4. **AT requirements in the receiving environment** are identified during the transition planning process.
5. Transition planning for students using assistive technology proceeds according to an **individualized timeline**.
6. Transition plans address specific **equipment, training and funding issues** such as transfer or acquisition of assistive technology, manuals and support documents.

Administrative Support

1. The education agency has **written procedural guidelines** that ensure equitable access to assistive technology devices and services for students with disabilities, if required for a free, appropriate, public education (FAPE).
2. The education agency **broadly disseminates** clearly defined procedures for accessing and providing assistive technology services and supports the implementation of those guidelines.

3. The education agency includes appropriate assistive technology responsibilities in written **descriptions of job requirements** for each position in which activities impact assistive technology services.
4. The education agency employs **personnel with the competencies** needed to support quality assistive technology services within their primary areas of responsibility at all levels of the organization.
5. The education agency includes **assistive technology in the technology planning and budgeting process**.
6. The education agency provides access to **on-going learning opportunities about assistive technology** for staff, family, and students.
7. The education agency uses a **systematic process to evaluate** all components of the agency-wide assistive technology program.

Professional Development and Training for AT

1. Comprehensive assistive technology professional development and training **supports the understanding that assistive technology devices and services enable students to accomplish IEP goals and objectives and make progress in the general curriculum**.
2. The education agency has an AT professional development and training **plan that identifies the audiences, the purposes, the activities, the expected results, evaluation measures and funding** for assistive technology professional development and training.
3. The content of comprehensive AT professional development and training **addresses all aspects of the selection, acquisition and use** of assistive technology.
4. AT professional development and training addresses and is **aligned with other local, state and national professional development initiatives**.
5. Assistive technology professional development and training includes **ongoing learning opportunities that utilize local, regional, and/or national resources**.
6. Professional Development and Training in assistive technology follows **research-based models for adult learning that include multiple formats and are delivered at multiple skill levels**.
7. The effectiveness of assistive technology professional development and training is **evaluated by measuring changes in practice that result in improved student performance**.

How Are We Still Growing?

The quality indicators for AT have led to the development of other indicator areas. QIAT for students in postsecondary settings were developed in 2009 (qiat-ps.org). In 2018, quality indicators addressing students who are served under Section 504 were developed ([Quality Indicators for Assistive Technology Within 504 Plans](#)). Other areas of growth include continued conference presentations, state level implementation projects, district level implementation, videos, book studies, and a mentoring project.

QIAT Videos

In 2014, AbleNet company invited the QIAT Leadership Team to provide a webinar series that resulted in ten introductory videos. These videos provide a foundational background to the work of QIAT and the QIAT tools and resources.

In 2018, another set of introductory videos were created by the QIAT Leadership Team as a part of a multi-year grant from the New Hampshire Department of Education (NHDE) to the New Hampshire Assistive Technology Project ([NHATconnect](#)). These short videos of about 10 to 20 minutes each, highlight critical ideas within each of the eight areas (see Table 3 for a list of free videos about QIAT). There are other videos available from ATIA for a small fee. The QIAT Indicators and the QIAT Matrices which form the foundation of these videos are located under the [Indicator and Matrices tab](#) on the QIAT website ([qiat.org](#)).

State Level Implementation

Many states have included the QIAT in their state AT manuals (e.g., Illinois, Maryland, Ohio). Other states have used the QIAT for many years in training to demonstrate and support the improvement of AT services to students with disabilities (e.g., Arizona, Texas, Virginia).

Minnesota Department of Education used QIAT to develop a Continuous Improvement Plan in 2002 with AT identified as a priority area (Breslin Larson et al., 2004). They developed a research study on capacity for AT using the Quality Indicators self-assessment matrices to determine status and identify gaps. Special education directors were specifically asked to complete the survey themselves, rather than assign it to another individual. The findings showed that special education directors realized how much they didn't know. They scored the administrative matrix for their own practice as quite low, and actively sought out support from the Department of Education (see Table 4 for more detail on the Minnesota plan). The survey was repeated after four years to a similar audience. Growth was seen in all regions that had received targeted professional development in identified indicator areas, but gaps still remained in other indicators, which indicated a strong need for ongoing professional development activities statewide.

District Level Implementation

While there are no data about the number of school districts who have used QIAT to analyze and improve their AT services, there is anecdotal evidence of its value from presentations at national AT conferences. On several occasions, QIAT Leadership Team members have invited school district personnel to share their experiences. For example, at the 2014 ATIA Conference, staff from Salem-Kaiser School District in Oregon talked about their use of the QIAT self-assessment matrices in 2006 and then again in 2014. Their first assessment showed that they needed to focus on including AT in the IEP and on implementing AT use in the classroom as well as increasing administrative support and professional development opportunities. Their assessment provided specific data and helped them figure out where to start based on that data. They stated that use of the self-assessment helped administrators and AT team members to focus on the overall AT program and their processes in addition to the daily tasks of selecting, obtaining, and implementing AT tools. It provided structure and guided the identification of goal setting. They described the QIAT self-assessment as a good tool to identify areas of need and to track progress over time (QIAT Leadership Team, 2014).

QIAT Book Studies

In recent years, several book studies focused on QIAT books have been hosted by statewide Assistive Technology projects (e.g., Washington, Virginia, Nebraska), by individual school system AT programs, and most recently, by members of the QIAT Leadership Team at the national/international level. Kristin Leslie, occupational therapist (OTR) and assistive technology professional (ATP), Director of Special Education Technology Center (SETC) for the state of Washington, describes how they have used book studies to support their school districts:

*In the 2015–2016 school year, SETC decided to work with educators in Washington state on building the capacity of Assistive Technology teams. During an in-person training, we found that many AT specialists felt isolated and needed ongoing support to shift their practices to more of a capacity building model within their districts. The following fall, we decided to conduct a book study using *Quality Indicators for Assistive Technology: A Comprehensive Guide to Assistive Technology Services*. At that time, we were still in “presenter” mode, meaning we felt the need to create a PowerPoint and have a presentation for those who attended each session of the book study. However, the power of shared experiences proved far more effective than SETC staff presenting the content. As educators delved into the pages of the QIAT book, they shared their own stories of applying the indicators in their schools. These stories bridged the gap between the written indicators and practical application to services to students.*

SETC held a QIAT book study series two years in a row, with 37 districts participating. In 2018, we created an eLearning course through Evergreen State College in Olympia so that districts could hold their own book studies. Through the eLearning course, an additional 117 educators across 55 districts in Washington state have participated.

What does this mean for AT practices in Washington? An AT survey conducted in 2017 with 55 districts showed that 51% of school districts in Washington had AT processes in place; however, these processes were not widely known within their districts. This survey represented districts that have AT specialists on staff. We suspect the percentage would be much lower if it had been conducted across all 313 school districts. Within the 2023–2024 school year, we will be conducting this same survey on a wider scale.

The QIAT website and book continue to influence professional development on AT practices in Washington state. Last year, we placed our book study recordings on the SETC YouTube channel where it has been viewed 461 times. In January of 2024, we will be launching a new eLearning course using QIAT that will focus specifically on AT Consideration, Assessment, and Implementation. This series will address AT practices at the IEP team level. We will also offer district leaders coaching on developing strategic district-wide plans for AT capacity building (K. Leslie, personal communication July 22, 2023).

Mentoring Project

Following the unexpected death of Joy Zabala in 2021, the leadership team worked with Joy’s family, her colleagues at CAST where Joy was the Senior Technical Assistance Advisor, a representative from the Assistive Technology Industry Association (ATIA) where Joy served as Conference Education Chair, and the broader AT community to develop the Joy Zabala Fellowship. The fellowship award goes to mentor and mentee pairs to develop outcomes that contribute to the fields of assistive technology and accessible educational materials. The application and award process were developed and have been received with widespread interest. The QIAT self-assessment matrices are a key component of the application process. Fellowships were awarded to three mentor/mentee teams for the 2022–23 school year and to three more for the 2023–24 school year. Individuals can apply as a team or as a mentor or mentee seeking to be matched with another. Applications for the following school year are available each February. Contributions are sought on an ongoing basis to maintain the fellowship program. Information to apply to participate and to donate to continue the program are available from CAST. ([The Joy Zabala Fellowship: https://www.cast.org/get-involved/joy-zabala-fellowship-assistive-technology-accessible-educational-materials](https://www.cast.org/get-involved/joy-zabala-fellowship-assistive-technology-accessible-educational-materials)).

Outcomes and Benefits

Zabala (2007) conducted research for her doctoral dissertation that evaluated the quality and usefulness of the six areas of QIAT that existed at that time (Administrative Support, Consideration, Assessment, Including in the IEP, Implementation, and Evaluation of Effectiveness). Zabala surveyed 120 leaders in the field of assistive technology including 1) consumers of AT services and family members, 2) district and regional AT leaders, 3) state and national AT leaders, 4) AT leaders in higher education, and 5) AT policy leaders. Results of her study suggested that quality indicators were needed to guide the development and delivery of AT services, that the 39 quality indicators contained in QIAT were important, and that they would be useful to people with varied interests and responsibilities in AT.

Two types of data were collected with the survey instrument used in the investigation. Quantitative data were collected by a forced-choice rating of each item in the survey. Most items offered four responses, though those concerned with the clarity of intent statements offered only two. The second type of data collected were optional reviewer comments on each item and optional suggestions for additions or revisions to QIAT. Comments were analyzed qualitatively. They helped to inform revisions that led to better clarity in the original six areas and the additional two areas (Transition and Professional Development) which were developed after the study was conducted (Zabala, 2007). The quality indicators were revised in 2005, 2012, and 2015 based on Zabala's research and feedback from the field. QIAT has changed the conversation about AT services. It has created a way to have dialogue about the development and delivery of services that can be fruitful across service models and that includes all perspectives.

Future Directions

QIAT has grown to include many components and has been used extensively across the United States. Blair (2008) stated that "the QIAT Consortium's Quality Indicators for Assistive Technology Services has done great work in developing indicators for effective state and district policies. He advises administrators to pay attention to those indicators as they implement their ed tech systems (p. 9)."

When surveyed, respondents have universally stated that they found the QIAT to be beneficial. States have incorporated them into their professional development and included them in their state technical assistance manuals. Individuals across the country have commented that the QIAT was "invaluable," used in all areas of their AT service delivery, and a "tremendous" help to them. For example, Janice Reese, occupational therapist, educator, and long-time Assistive Technology Professional (ATP), commented:

I manage the Assistive Technology for Kids Center (AT4Kids) at the Little Tennessee Valley Educational Cooperative (LTVEC). AT4Kids provides direct services and training to school districts across East Tennessee. I am also a founding member of the Tennessee Association for Assistive Technology (TAAT) and Lead Coordinator for the annual state conference of the same name. I have utilized the quality indicators in all aspects of my work and wanted to share our plan for using them to guide the provision of AT support/services in Tennessee schools through a new endeavor.

While working under a TN-DOE grant to address the AAC needs of students with complex communication challenges (2018–2023), I introduced the state's Related Services Coordinator to the Quality Indicators. When the department decided to add assistive technology support to the new Technical Assistance Network (TN-TAN), she used them as a guide. My agency was awarded the contract in February 2023, and has begun assembling a team of skilled clinicians and educators to develop a wide scope of proposed services. The goal of the new Tennessee AT Project is to reduce the barriers that impede student access to AT by improving district policies and practices, increasing staff knowledge and skills, providing resources and guidance, and enabling access to devices through creation of regional lending libraries. Our contract mandates that the QIAT self-assessment matrices be used for pre/post assessment of all facets of AT service delivery and training at the district level and for individual personnel entering our trainee program. Findings from these matrices will guide the development of customized improvement plans and for tracking progress (J. Reese, personal communication, May 25, 2023).

QIAT development work has always been done on a voluntary basis. It has been led by several of the individuals who attended that first three-day meeting in 1998. Over the years, they called themselves the QIAT leadership team. New members have been added to the leadership team in the last two years to bring more current experience and new perspective. The leadership team continues to look at additional areas that may benefit from quality indicators related to the provision of AT. Gersten and Edyburn (2007) suggested that the indicators could be expanded to include research related to AT. A request was recently received seeking permission to translate and adapt the QIAT for use in improving AT implementation throughout Poland (A. Kochanowicz, October 29, 2023). Other areas have also been suggested and discussed by the leadership team, including quality indicators that are more specific to AT use in early childhood and quality indicators for use of AT in high stakes assessments. These suggestions provide valuable ideas for future directions.

No matter how much more the idea grows or what the future holds for the continued use of QIAT, one of the most important things they have brought to the field has been the focus on the need to work collaboratively together. Zabala (2005) highlighted the critical elements of shared knowledge, collaboration, communication, and the inclusion of multiple perspectives when making decisions about AT and other supports for students with disabilities.

- **Shared Knowledge:** Decisions are most effective when made by a team based upon mutually valid shared knowledge.
- **Collaboration:** Efficient and effective implementation of AT depends upon collaboration between the decision makers and all the individuals impacted by the decisions.
- **Communication:** Shared knowledge can only develop when the opinions, ideas, observations, and suggestions of all involved are both respectfully shared and respectfully received.
- **Multiple Perspectives:** Although multiple perspectives can be challenging at times, they are critical to the development of shared knowledge and the effective use of AT.

Zabala was writing specifically about the SETT framework in this publication, but her influence ensured that those same elements are an integral part of the quality indicators. The use of QIAT encourages communication and collaboration from multiple perspectives. This contributes significantly to their ongoing value to the field.

Declarations

This content is solely the responsibility of the authors and does not necessarily represent the official views of ATIA. The authors disclosed a financial relationship. They are the authors of the QIAT books receiving royalties. All have a non-financial relationship with ATIA. In addition, Kelly Fonner has a financial relationship to ATIA.

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Voices from the Field

How Far We've Come: How Assistive Technology Changed the Game

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Abstract

This Voices from the Field account brings together a project participant and project staff to discuss the benefits of using assistive technology (AT) for women veterans with traumatic brain injury (TBI) in higher education. These include increased knowledge of AT, rights related to AT, developing an understanding of their TBI, and support for academic and professional success. Assistive technology plays a positive role in advancing the outcomes for women veterans in higher education and paving the way for future success.

Keywords: women veterans, traumatic brain injury, higher education, disability, assistive technology

How Far We've Come: How Assistive Technology Changed the Game

Project Achieve was a 3-year grant demonstration project funded by Commonwealth Neurotrauma Initiative (CNI), focused on using Assistive Technology (AT) with women veteran students with a traumatic brain injury (TBI) and/or spinal cord injury (SCI) enrolled in higher education programs. As a result of their TBI/SCI, it was common for participants to experience problems with learning and memory, organization, stress management, and anxiety. To address the issues that affected academic performance and quality of life, project participants received personalized iPads and apps, and worked with Technology and Employment Counselors (TECs) trained to provide individualized case management. The authors give first-person accounts to show the viewpoints of a project participant, Katherine. She describes the benefits she experienced learning about and using AT, understanding her TBI, and identifying the support she needed for academic and professional success. For Katherine, AT was a “game changer.” Depicting the viewpoint of the Technology and Employment Counselor (TEC), Jan, Katherine’s personal insights, and the experience of fellow TEC, Kelly, this paper showcases the multifaceted ways that AT can create positive change.

Personal Statement by Jan Shea

I am a social worker by training. I started as a Technology and Employment Counselor (TEC), or a specialized support coach, for Project Achieve after the program started. When I joined the project team, my knowledge surrounding the women’s veteran population came from research and training workshops. This was not enough. I needed to dive deeper into the array of AT options and explore my own personal biases or misconceptions about women veteran students with TBI. No amount of research or training could have prepared me for the complexities and magnitude of working alongside this population. When I met Katherine for the first time, I took note of the many identities that intersected within her. In reflection, I now know that this experience deeply shaped my working knowledge about the vital role AT plays in a person’s life.

Meeting Katherine allowed me the chance to hear about the lived experiences of a Latina woman veteran. I witnessed the intersections of Katherine as a first-generation college student and first-generation American. The intersectionality of Katherine’s experiences guided me to explore the complexities of TBIs, the individual impact of acquiring a disability later in life, and the ramifications of multiple systems not properly educating an individual about their rights, their medical condition, and the resources available to them.

I was not part of the team who completed Katherine’s intake paperwork, but I noted that in her first assessment, Katherine chose mostly neutral choices related to her confidence in navigating various areas of her life. In reviewing her information, I saw a woman with exceptional skills who struggled to accomplish the goals she developed for herself. When Katherine and I first began working together, a gap existed between our individual working knowledge of assistive technology. Though Katherine was not familiar with the term “assistive technology,” she nonetheless relied on the technology daily. While not outright calling it “AT,” she understood the ease of using the Reminder App, the calendar app, and GPS apps. She relied on family and friends to support executive functioning tasks for memory and navigation. My experience with AT skills revolved around individuals accessing materials through screen readers, programs that supported speech-to-text functions, and other very specific AT goals. My time with Project Achieve helped round out my understanding that AT has a place in daily life, something particularly brought into focus from my experience watching Katherine and the other participants.

Watching Katherine navigate complex systems within academia, the military, and medical institutions shaped my empathy and professional growth for a population that is largely underrepresented in both research literature and resources. It is the author's hope that this field account will contribute to readers' understanding and knowledge of the role that AT can play in supporting college students with TBI and other disabilities.

Target Audience and Relevance

Important conversations related to higher education are less likely to include students with disabilities than other historically underrepresented groups (Yoho, 2020). Research about women veterans and disability lags behind the vast body of literature related to veterans (Lau et al., 2020; Meltzer & Juengst, 2021). Additionally, the percentage of women experiencing a TBI has increased over the past decade from 25% to 40% (Oyesanya & Ward, 2016). The intersectionality of a woman veteran's identity is not solely shaped by their experiences while serving, but also by incidents of racism, classism, sexism, and other means of discrimination and oppression during their service and when transitioning back to civilian life (Meade, 2020). These experiences, coupled with acquiring a TBI or other disability later in life, fundamentally alter an individual's identity and trajectory. For Katherine, her acquired TBI while in active military duty changed her trajectory and interactions with institutions, systems, and support systems exponentially.

Katherine was completing her second semester at a community college prior to enrolling in Project Achieve and reported difficulty with concentration, memory, and organization to project staff. During the first months with the program, project staff worked with Katherine to identify apps specifically to address memory recall and read-aloud applications. Katherine also learned about the community college's disability support services office through project staff. Initial conversations about smart devices and Apple Air Tags to assist in executive function tasks (i.e., remembering to turn off appliances or lock doors, or locating items) made for a starting point for better understanding of her individual AT needs.

Disability support services personnel, academic advisors, and higher education professionals working with special student groups (e.g., military support services, first-generation students, transfer students, international student organizations) would benefit from this article to expand their knowledge of assistive technology resources within their higher education institution and abroad. Each of these units plays a vital role in supporting students on a college campus. It is important for college faculty and staff to learn the rights and responsibilities associated with AT for students, to increase their understanding of TBI, and to see not only how students can succeed but where AT contributes to those successes.

Literature Review

The veteran population continues to be one of the fastest growing populations in the United States, with women representing the most growth (as cited in Lau et al., 2020). Services for veterans exist to address needs they may encounter during the reintegration process back to civilian life. There are myriad military-to-civilian transition services available for veterans, ranging from financial assistance, housing, physical and mental health, vocational, and educational. Perkins et al. (2020) points out that a substantial portion of the veteran population report difficulty during the reintegration process. This is further compounded within the women veteran population and veterans with physical or mental health needs (Belmont et al., 2010; Lau et al., 2020).

Looking at military transition through the intersectionality framework coined by Crenshaw (1991) allows the authors to acknowledge the natural intersection that a veteran can be a woman, a person with disabilities, Latina, a student, and more. The intersectionality perspective allows for the natural examination of multiple social and cultural identities in the context of an individual's lived experience. Bowleg (2012) further supports that this framework creates a viewpoint where identities across multiple points can coexist amid places of privilege and oppression. No social category is more valuable than another identity, thus allowing those in higher education to view each intersectionality for its unique perspective. Katherine's lived experience is a testament to viewing veterans from an intersectionality framework. Furthermore, Katherine's transition experience from military to civilian life is not an anomaly as the research shows. With the added complexity of an acquired disability, support is vital for that transition.

The research reveals the importance of supports and services for women veterans with disabilities, given that they are at a greater risk for developing psychiatric problems after TBI and that the prevalence of post-9/11 women veterans receiving a positive TBI screen is between 11–13% (Fann et al., 2004). Recognizing the importance of supporting this population, AT emerges as a proven asset. AT helps individuals comprehend how their TBI affects daily functioning and finds ways to enhance functionality. The needed supports, as found in the literature and the field experience described in this article, align with the need for increased knowledge of AT, awareness of rights related to AT use in higher education, understanding the complexity of TBIs, and how to use supports (including AT) for success.

Knowledge of AT

At the 2022 ATIA Conference, Ligon highlighted the unique needs of the women veterans participating in the study. Participants not only struggled with accepting that their injury would impact their education, but also with navigating disability-related support systems. Most participants were unfamiliar with AT and its use in providing equal access. Many participants were hesitant to trust others. Military culture was to push harder rather than seek help. Ligon (2022) shared that as participants grew in their knowledge about AT and learned to use technology, their confidence increased, and performance improved on class assignments. Through the project, participants became familiar with AT and began to connect its features to the solutions they needed. TECs guided participants to understand that AT includes devices and services that improve the functional ability of a person with a disability for daily living, learning, and working.

There are four main levels of AT devices used by students and disability support services offices within higher education. The four main levels are:

- No-technology intervention, such as agenda book or pencil grips;
- Low-tech, such as calculator or recorded lectures;
- Medium-tech, traditionally seen as mechanical devices to aid in mobility, or adapted keyboards; and
- High-tech, such as advanced technology software, wheelchairs, devices, iPads, and apps (DeLee, 2018).

The majority of technology employed by support services for many years fell between the no-tech to medium-tech levels, and relied heavily on support staff personnel to manage, initiate tasks, and provide solutions for others. With the advancement of technology, accessibility solutions are now built into homes, computers, and cell phones. When a student finds the correct combination of AT devices and services, their likelihood for success and independence increases. In fact, accessing AT specific to one's unique needs in college leads to lessened feelings of isolation, improved academic performance, and increased self-reliance for students

(Ahmed, 2015; Chun & Williams, 2021; DeLee, 2018). Furthermore, research by Chun and Williams (2021) regarding the importance of the development of a community of practice related to accessibility and technology in higher education outlines the value of faculty and staff members gaining access to “safe interdisciplinary learning environments” (p. 135) where they can meet regularly to discuss technology integration to meet accessibility needs.

Understanding AT Devices and AT Options

Students, especially those with self-awareness and self-advocacy skills, can contribute to understanding and identifying the type of AT devices and services they need for success in higher education. While different levels of AT exist, higher-education institutions that adopt a universal design lens increase access for all students through inclusive policies and practices (Parker Harris et al., 2019). Aside from disability support staff at higher education institutions, Chun and Williams (2021) point out the importance of librarians, educators, and other college support staff having a basic understanding of AT, and how to incorporate this technology into lessons and materials. Accessing AT is not a one size fits all solution for students with disabilities. It is important that each individual is aware of what AT best suits their needs. Students need to have the freedom and opportunity to have an open dialogue with well-informed staff and faculty about those needs. When students and college staff are knowledgeable about the types of AT available, the discourse necessary to success and access is possible (Chun & Williams, 2021; DeLee, 2018; McNicholl et al., 2023). When participants like Katherine became connected with their colleges’ disability support services offices and began expanding their use of AT devices into regular habits, noticeable achievements occurred. A very tangible example of this is students using their iPads to join virtual classes when suddenly confronted with all online learning, as occurred in 2020. This freed up their laptops to allow for note taking, following along with presentations, and viewing class materials on a larger screen.

Awareness of Rights Associated with AT in Higher Education

It is critical for students to be aware of the rights available to them and the laws in accessing AT while in college. American with Disabilities Act of 1990 (ADA), the American with Disabilities Act Amendments Act (ADAAA), Rehabilitation Act of 1973 (Sections 504), and the Assistive Technology Act (ATA), first passed in 1988, are the four pieces of legislation that ensure access to reasonable accommodations, and guarantee equal access (DeLee, 2018). With the increasing trends of students with disabilities attending college (Clay, 2023), there is a growing research need to ensure that this student population is aware of what accommodations are available at their institution, has knowledge about the laws supporting them, and how they can work with the disability support staff to adjust or change accommodations as needed.

Understanding TBI and Support

In Oyesanya and Ward’s (2016) article on the mental health of women with TBI, they cite research that has shown that some groups are at higher risk for sustaining a TBI than others. In addition, the individual impact of a TBI varies in terms of severity, length, and areas of impact. They further state that the percentage of women experiencing a TBI has increased over the past decade from 25% to 40%. Meltzer and Juengst (2021) found the underrepresentation of women and exclusion of their experiences in the vast majority of TBI research.

Furthermore, TBIs, when viewed as chronic conditions, require education on the part of the individual who sustained the TBI, as well as on the part of their family and loved ones supporting them. The educational component surrounding understanding one’s TBI varies and is frequently presented through a medical model

approach. Diagnosis and education about TBI developed and delivered by medical providers or staff shape an individual's foundational knowledge of TBIs (Hart et al., 2018). Unfortunately, this medically focused explanation of a TBI does not adequately prepare an individual or their family to identify supports available to them.

Below is the lived experience of Katherine. The literature suggests that Katherine's experience is not unique, and unfortunately, many have shared similar experiences of healthcare providers or facilities that were ill-equipped or unprepared to provide education about the scope of TBIs and the individual impact a person may experience.

Katherine's Experience

I am Katherine Martinez. I'm a first-generation American, first-generation college student and graduate, an English as a Second Language (ESL) learner, and the only person in my family to serve active duty in the military. But most importantly, I am a woman veteran. I served in the United States Navy from 2015–2019 as a sonar technician; however, an injury in the line of duty in August 2017 changed my life forever. I would not realize the impact until late 2019.

While stationed in August 2017 aboard the USS Winston S Churchill, I was a part of the ship's Color Guard. In my day-to-day operations, I served as a sonar technician, but on August 25, I was serving under the Color Guard, as a collateral duty. We would render honors at several ceremonies, but this day was different. The commissioning officer of the ship was retiring, which meant people from all over the world were in attendance and perfection was expected. To make a long story short, I presented the colors, went to return my rifle, fell down a vertical ladder well and hit my head. No medical emergency was called. I drove myself to the emergency room. I spent five hours without a single screening. No x-ray, no MRI, no CT scan was ordered. There was more of a focus on how my scar would heal than the damage done by the impact of the fall. I had sutures placed and was sent home.

I wouldn't get an x-ray until seven months after my accident and wouldn't be diagnosed with a traumatic brain injury until January 2019. Even then, I had no idea what that meant. I was given this diagnosis to put me through a medical board. A medical board is a process in the Armed Forces where a service member's medical record and referring condition is evaluated by a team of doctors and they determine if a service member is fit or unfit to continue military service. I asked the neurologist what having a TBI meant. It was a brief conversation, and he did not really explain what it is or what led him to this diagnosis. I went into my medical board hopeful. However, I was medically separated from the Navy on October 29, 2019.

Before my time in service ended, I started my academic journey in the summer of 2019. I attended Tidewater Community College. After my first semester, I realized I was no longer learning the same. I was struggling. My ability to recall was terrible, I couldn't remember, and I constantly lost things like my keys, as well as my glasses. I didn't know what was going on. But I continued with my studies, registered for the fall semester, and realized that I was still having a hard time. I didn't know what I was going to do but knew something had to change.

In December, I connected with the veterans' liaison on campus about running a Student Veterans of America chapter. When I mentioned my diagnosis of TBI, she forwarded me an opportunity from Virginia

Commonwealth University called "Project Achieve." The email described it as a research study to assess the benefits of assistive technology for women veterans with TBI and SCI. I saw TBI and wanted to know more. At the time of my diagnosis, I got no explanation of what that meant for me, my life, or if it could be treated. I wanted to know more but was hesitant, as I did not consider myself a veteran at the time. I got out of the military, but I was medically separated. I didn't feel that I should call myself a veteran even if I did serve four years. I didn't want to take an opportunity away from a veteran who needed it more than me. However, after more conversations with the veterans' liaison, I applied, and would later find out I was accepted. Once the program kicked off I was assigned a "coach," Jan Shea, and she changed my life.

While she followed the study protocol, she was committed to finding tools, apps, or resources that worked for me. One of the first things we did was go over my diagnosis of TBI, including what happened the day of my accident and explaining how there wasn't much medical concern about my head injury. From there we went into what I was struggling with, what I've tried, and what I had hoped to gain from being in Project Achieve. For three years we'd communicate on what did work, what didn't, but over time saw my growth. I gained more confidence in the classroom, found tools that worked for me, and using the AT devices became more natural, rather than a forced task.

Project Achieve gave participants an iPad and a gift card to buy apps, if needed. I used several apps and landed on a few that I still use to this day. Those apps included programs for reminders, password keeping, and innovative ways of keeping notes. These apps included GoodNotes 5, the modes and routines function on my Android, as well as the ability to set up my home phone screen with widgets that I could [use to] program a to-do list and [make] my daily schedule.

To reiterate, the results of finding AT devices that worked for my specific needs was life changing. I began to notice I was doing better in school. I was engaging with my community. I was able to manage time for my work, course work, and passion projects. I graduated with a Bachelor of Science Degree in Sociology and Criminal Justice. I was named the 2021 Student Veteran of the Year by the Student Veterans of America at their 2022 national conference, NATCON. When this moment happened, it felt surreal, and I reflected on how far I had come from when I started my academic career. But, from that moment on, I was able to have a platform where I could share the importance of accessibility in higher education by bringing attention to Project Achieve, my personal experience, and how imperative social mobility is. I developed my other passions which include intersectionality, mental health/suicide prevention, and health care accessibility.

In 2022, I started studying the experiences marginalized communities faced within medical care in the Armed Forces and learned that my experience was not an isolated one. Eighty percent of women I spoke with, representing many ages, ethnicities, and education backgrounds, had experienced, at some point, mistreatment, or had their concerns dismissed by a medical provider. I obtained this information from a survey I created. These data were then used to develop a presentation called the "Unknown Diagnosis" for NATCON 2023. The room was full of attendees, and they asked questions. They wanted to know what they could do to help others and shared their own stories. This led me to decide where I want my career to go—moving away from criminal data/statistics to engaging with the policies, legislation, and practices that impact the quality of medical care [that] individuals from vulnerable populations receive from providers as well as increasing the opportunity for diagnostic medical research to be more inclusive of: women, racial/ethnic minorities, and sexual and gender minority populations.

Katherine and Jan's Work Together

Katherine

Initially I was introduced to another staff member in Project Achieve in December 2019; however, I would later be introduced to Jan Shea in early 2020. The first member of the team did my initial intake and asked for my needs and what I felt I struggled with the most. I had mentioned my short-term memory was awful. I would often forget tasks like chores, where my car keys were, and even where my prescription glasses were (even if they were on my face). I wanted to do a better job of keeping track of where my items were but be better at managing my daily schedule.

Jan

I jumped in as Katherine's TEC after she got started but we quickly developed a good working relationship. We utilized Zoom, emails, and text messaging to conduct our check-ins. Everyone was struggling to adjust to a fully virtual lifestyle but there were some benefits; we were able to share our screens during Zoom calls to see issues in real time or for Katherine to show barriers.

Katherine

Prior to my accident, my learning methods were different. I would review visually and would have no trouble recalling. When I initially went back to school, that was not the case. Nothing was sticking and it was embarrassing to say that I couldn't remember things. Everything I knew about memorization and learning was no longer working, and I was lost.

In this stage of being lost, I had the unique opportunity to learn new things that were working, but also to unlearn what was not. Before, I could read things and rehearse it over and over again to remember; I could no longer do that. However, writing things down was what I learned worked for me. Once I knew that, I struggled to break my old habits of learning. When I would start to do better in school I would convince myself that I could do what I did before, which was just reading. It wasn't sticking. So, with support from Jan, I began being honest with myself on my limitations and sought ATs that would support what I needed. I looked for AT that did more than mend my initial needs, it helped build habits. For example, like writing things down in a place I could refer to immediately; instead of losing it, noting where I have left things (versus just taking pictures, and using sticky notes), and my favorite thing, programing my cell phone to have reminders and widgets based on what I needed instead of feeling I had to carry a notebook everywhere.

Jan

We worked on how to make the device that went with her everywhere, her Android phone, her biggest AT champion. It was also during one of these meetings where Katherine trumped me by sharing that she had found GoodNotes 5. She had followed the recommendations from the iPad based on the apps we had been suggesting. This single app became one of Katherine's strongest AT tools and quickly was shared with other participants. On the flipside, I quickly learned that the recommended app to use Google calendars for Katherine was not helpful and quickly discarded it, as the Android calendar met her needs.

Our times together extended past apps. We talked about Katherine's goals, such as securing an internship through Washington Career Center or a career with the federal government. One of my first areas of support for Katherine was following up on a recommendation to get connected with her campus's disability support services office. What I was reading and seeing in our calls was this talented young woman who could benefit from tapping into the services at her college campus and integrate those supports across her life.

Katherine

I remember telling my professors that I was struggling, and I didn't understand why. They gave me grace, courtesy, and understanding when I didn't even understand what I could ask for. The veterans' liaison helped me immensely by telling me about Project Achieve, but over time Jan would suggest not just ATs, but other means of support to reinforce what my AT was helping with. For example, in trying to phrase what I needed, rather than ask if something did or did not work (in a yes/ no format), Jan would ask if [the app] helped with anything. And if so, what did I find useful about it? Before making another suggestion on trying something new or staying with what I have, we broke down what was or wasn't working. Once this happened, I felt more confident in our monthly check-ins which turned more into candid conversations. Because rather than saying x, y, and z didn't work, I could explain how I was doing better or would even ask about another AT device that I would stumble upon.

Jan

Over the course of several months, Katherine got connected with DSS, found apps that were working, and incorporated AT devices into her daily routines. From my perspective, it was like watching the pieces line up. Katherine began finding a stride and the accomplishments began rolling in. Our check-in meetings usually started or ended with Katherine sharing another award, achievement, or advancement she was making professionally and academically. Katherine and I worked together from March of 2020 until June 2022 without ever meeting in person. On June 7, 2022, I met Katherine for the first time in a coffee shop for some of our final assessments. Katherine and I had known each other in our professional capacity for so long but the meet-up felt more like a reunion than an in-person assessment.

Discussion

Through Project Achieve, we learned that a gap exists in postsecondary education among service providers across college campuses. In particular, women veterans in higher education with disabilities do not know that disability support services exist or how they might qualify. Project participant and fellow author, Katherine, shared the personal growth she experienced both academically and emotionally when she finally connected with the disability support services at her university and learned about AT through the project. Collectively, the authors explore challenges facing women veterans in postsecondary education and propose adopting universal design and accessibility practices to enhance inclusivity and reduce barriers.

Issues, Needs, and Service Gaps

While working with participants, project staff identified issues, needs, and service gaps that required attention. Like Katherine, helping participants remove the stigma around having a disability and informing them about the laws that protected their rights in higher education was a necessary first step. The primary issues identified by participants included challenges with understanding their own learning needs as a result of their acquired TBI and knowing what accommodations and AT resources were available. Finally, gaps in collaboration between campus services, like military student services and student accessibility offices, had a negative impact on participants' initial performance in higher education.

Participants in the project acquired their TBI as adults and shared similar challenges as they navigated a new way of living and learning. For example, during initial conversations, many participants expressed feeling overwhelmed, distracted, and disorganized. They reported difficulty remembering things related to school and

household tasks, such as turning off the stove or locking the door. Participants also mentioned experiencing anxiety, physical and mental fatigue, and uncertainty about where to seek help. Adjusting to civilian life was also difficult. As veterans, they found it challenging to transition from the structured military environment to college where they were responsible for managing their time. Many participants had held leadership roles in the military and returning to school felt like a step backward. As a result, they struggled to adjust to higher education demands, which led to many not disclosing their disability, distrusting others, and not seeking accommodations.

Prior to joining the project, to cope with these challenges, veterans reported using strategies such as exercising, journaling, and using calendars and alarms on their phones. They also found it helpful to study in quiet and clutter-free environments and relied on family and friends for support with managing their daily routines related to college. Some connected with the military student services offices on campus and used the services they provided. Yet, participants were unaware of their rights under the ADA and the accommodations available to them in college. This highlights the importance of collaboration between campus disability support services offices and military student services offices to enhance access, better serve, and meet the needs of student veterans with disabilities.

Implications for the Field

More women veterans are attending higher-education programs, and this trend is likely to continue (Lau et al., 2020). Project Achieve demonstrated the benefit of specific technology support and access for diverse populations. Two primary approaches in the literature for increasing access are accommodations and universal design in higher education environments, systems, and practices (Parker Harris et al., 2019). Reasonable accommodations, as covered under ADA and Section 504, provide campus disability support services the tools to support the individualized needs of students. However, research has shown that barriers exist related to implementation of accommodations such as documentation requirements, lack of faculty knowledge of accommodations, concerns about special treatment, and other factors (Parker Harris et al., 2019). Alternatively, developing policies and strategies around universal design may help to mitigate these barriers. Universal design's intention is to increase access to learning, decreasing any barriers to the educational process. Combining accommodations and universal design approaches to expand knowledge of faculty and collaboration across campus services may be a strong practice to adopt (Parker Harris et al., 2019). Additionally, sharing the responsibility of providing accommodations, AT, and universally designed instructional practices among campus services may build a more inclusive learning environment and decrease barriers for students with disabilities.

Outcomes and Benefits

Over the last twenty years, technology has become more accessible and mainstream. In today's modern world, everyone uses their cell phones, iPads, and computers on a daily basis for things like social interaction, way finding, and managing finances. People with disabilities who use technology for accommodations blend in and look like everyone, increasing their confidence in using the support. These common technologies have accessibility features for text-to-speech, speech-to-text, and word prediction, making assistive technology less costly because one device can meet multiple needs. As technology advances, individuals with disabilities will need to understand their rights under ADA to assist them in advocating and obtaining technology that can support their learning needs in higher education.

In Katherine's case, Project Achieve helped her accomplish more than she thought possible. With education of her condition, AT devices, and a team that didn't assume they knew her needs as a person with a TBI, but asked what she was experiencing, she prospered. Regarding AT, its daily use, and implications to her life, Katherine shares,

I use AT every day and share with others, whenever I can. So much so that my alma mater's university president agreed to upgrade the on-campus student veterans lounge with AT features so that it could help other students on campus. Those diagnosed with a chronic condition like traumatic brain injury can be [in] a whirlwind of emotions. Identifying how your diagnosis impacts your life, trying to find a sense of normalcy, and accepting the available resources can be a lot. However, with programs like Project Achieve and being able to share its impact on my life, I now know there is room to start conversations with other institutions to adopt something similar in their accessibility office, [for] employers to be more mindful of accommodations for their employees that live with TBI, and [to] bring attention to how assistive technology can aid in your everyday life.

I'm now studying for the LSAT exam with aspirations to study law. I am happy that I can use my routines on my phone to balance my work, study cycle, and personal life with ease. I'm glad to know of apps that can help me be a more efficient note taker as well as have the confidence to have an honest conversation with staff and my professors on the accommodations that have worked for me in the past. I'm proud that I can use what I've learned to keep moving forward.

The project's provision of individual case management and iPads with personalized apps yielded positive participant outcomes as reported in exit interviews and surveys. Some participants shared that Project Achieve provided them with the knowledge and confidence to connect with their campus disability support service office, while other students shared that they became better advocates for accommodations based on how their TBI diagnosis impacted their learning. Students looked to embed AT resources across their daily living routines and academic learning and began exploring where AT would support them with their employment goals. Ultimately, it provided a foundation for them to continue pursuing higher education, where they did not necessarily feel that way at the start of the program.

The project made available to each participant individualized academic support and technology by providing an iPad, individualized apps, and consultation support from a TEC. Participants met with their assigned TEC on a regular basis. This case management approach allowed students and TECs the opportunity to problem-solve issues related to daily functioning which in turn assisted participants with understanding and learning how to live with their disabilities. Participants also reported that having access to the iPads and suggested apps assisted with studying and learning material, allowing their confidence to be a successful student to grow, and increased participation in class discussions and improvement in grades as well. As their confidence rose, their motivation increased, and they were better able to explore apps and other technology to problem-solve on their own.

Pre- and post-assessments identified needs and gaps and recommendations for AT supports. During exit assessments, the majority of participants shared that they learned through the course of the project that they

preferred apps that reduced anxiety, increased focus, and assisted with time management, organization, and retention of class material. Many reported that using simple executive functioning solutions like reminders, alarms, and checklists helped them organize their lives so that they had energy to focus on the coursework. From an emotional standpoint, using the technology helped to boost their confidence in their academic abilities and employment opportunities. Additionally, access to iPads eased the transition to virtual learning at the onset of COVID-19 in 2020 and allowed students to more easily access the learning management systems. Finally, documentation from participants revealed that using mobile technologies contributed to their retention in their program of study, matriculation into four-year universities, and notable individual accomplishments.

Conclusion

The findings of Project Achieve suggest positive advancements in the field that will pave the way for the future. Student veterans are less likely to seek out services because the military trained them to push forward, finish the job, and not ask for help (Lau et al., 2020). To assist student veterans, a seamless provision of training and support services across student campus services may contribute to an increase in students disclosing their disability, furthering their academic success, and improving graduation rates. In addition to support services, social aspects of higher education can often be a barrier for individuals with disabilities (Parker Harris et al., 2019). Evolving AT solutions to meet the social and emotional needs of users may further personalize their experience and contribute to a sense of acceptance and inclusion in higher education. We would further suggest that individuals with positions of purchasing authority for departments and university-wide programs need to invest time and understanding of the accessibility of potential products and integration with a variety of AT options.

In addition, Lau et al. (2020) suggested viewing student veterans as their own cultural group and identifying the best ways to support them. Conceivably, a solution might be to broaden the features of AT devices to meet the unique needs of diverse groups such as the one described by the authors. Finally, within AT products, built-in training features, data tools, and suggested supports can maximize the use of AT devices and increase user independence and knowledge of potential accommodations. These new practices may improve learner satisfaction and increase the rate of program completion in higher education. Through increased knowledge of AT and a greater understanding of one's rights related to AT, women veterans with a TBI are advancing in higher education. While the research surrounding women veterans is not representative of this minority group, women are forging ahead to better understand their diagnoses and resources on college campuses. Assistive technology has shown to be a powerful tool to support academic and professional success.

Declarations

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