# *Assistive Technology*

## Outcomes and Benefits

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### *The Role of Research in Influencing AT Products, Policy, and Practice*

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# Assistive Technology Outcomes and Benefits
## *The Role of Research in Influencing Assistive Technology Products, Policy, and Practice*

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Assistive Technology Outcomes and Benefits (ATOB) is a collaborative peer-reviewed publication of the Assistive Technology Industry Association (ATIA). Editing policies of this issue are based on the Publication Manual of the American Psychological Association (6th edition) and may be found online at www.atia.org/atob/editorialpolicy. The content does not reflect the position or policy of ATIA and no official endorsement should be inferred.

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The Editorial Board would like to thank the peer reviewers who generously donated their time and talent to reviewing manuscripts for this Volume 13 of ATOB.

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# Assistive Technology Outcomes and Benefits
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## 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) marketing research related to AT demographics or devices and services; (c) technical notes regarding AT product development findings; (d) qualitative studies, such as focus group and structured interview findings with consumers and their families regarding AT service delivery and associated outcomes and benefits; (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.

*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.

*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.

*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.

## 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 experimental 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, techniques, 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, institutional, 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. Authors may describe their work as it relates to more than one audience, and should specify the value that each group may derive from the work.

## Publishing Guidelines

Each manuscript must reflect the style guidelines of the Publication Manual of the American Psychological Association (6th edition, 2009).

Manuscripts should be no more than 25 pages in length (double-spaced), including references, tables, and figures.

Due to the electronic format of the journal, all submissions should be submitted as email attachments in a Microsoft® Word format.

See the detailed Manuscript Preparation Guidelines for Authors for more information on formatting requirements and submission instructions.

## For More Information

Please see ATOB's Editorial Policy at http://www.atia.org/at-resources/atob for more details regarding the submission and review process, ATOB's Copyright Policy, and ATOB's Publication Ethics and Malpractice Statement.

# Assistive Technology Outcomes and Benefits
# The Role of Research in Influencing the AT Products, Policy, and Practice

Volume 13, Summer 2019

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# Introduction to Volume 13

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Welcome to Volume 13 of Assistive Technology Outcomes and Benefits (ATOB). It showcases articles that address the theme of "The Role of Research in Influencing Assistive Technology Products, Policy, and Practices." ATOB editors invited authors to submit articles that (a) address the ways that research, either internally within an organization or externally through successful private and/or public partnerships, has resulted in new assistive technology (AT) innovations, practices, and policies that help people with disabilities achieve their goals; or (b) highlight research findings that should inform product development, practice, and/or policy, helping to shape emerging and future technologies, strategies, and programs. In either case, manuscripts were required to draw conclusions about how research has been or can be used by other stakeholders to effect positive change for people who use AT. The editorial board had the good fortune to be able to offer our readers three thought-provoking examples of how research is informing the development of AT products, policies, and practices.

One of these pieces offers the perspective of the researcher. Its authors Kevin Pitt, Jonathan Brumberg, and Adrienne Pitt are from the Department of Speech-Language-Hearing: Sciences & Disorders at the University of Kansas in Lawrence, Kansas. Entitled "Considering Augmentative and Alternative Communication Research for Brain-Computer Interface Practice," it considers how research within the field of brain-computer interface (BCI) could be fruitfully incorporated into augmentative and alternative communicative (AAC) research and practice. This topic will engage researchers, practitioners, individuals who use AAC, and their caregivers, who are all instrumental to ensuring successful use of resulting products.

Another article brings a practitioner voice into the discussion about public school policy governing the provision of AT, where staff and students are using an increasingly broad array of technology. Aptly summarized in its title “School Technology: Moving Beyond Assistive,” the article was contributed by Carol Michels of the Northern Suburban Special Education District in Highland Park, Illinois. The work shares Michels’ insights regarding the need for AT departments and services to move away from policies that encourage referral-based deficit models for individual student remediation. Instead, she proposes developing a proactive framework that engages practitioners as "thought leaders, partners in programming, and experts in technology.” Her piece will be of high interest to AT providers, district- and school-based administrators and practitioners, students, and their families.

To understand the role research can play in the AT industry, turn to the article “Accessibility User Research Collective: Engaging Consumers in Ongoing Technology Evaluation.” John Morris, Nicole Thompson, and Ben Lippincott of the Shepherd Center joined forces with Megan Lawrence of Microsoft to summarize the development, current status, and impact of the Accessibility User Research Collective (AURC). AURC is a national network of people with all kinds of disabilities, who provide project-by-project formal customer feedback for Microsoft as it develops its products and services. The article offers an excellent example of collaboration between representatives from a tech company and accessibility researchers who work for a non-profit. Such interactions provide industry with valuable input from those who understand the needs of targeted product users. Like Microsoft, other companies could adopt this model to gather feedback to develop and refine their products and services, so that more customers might benefit from tech industry offerings.

In sum, Volume 13 dedicates itself to the theme of exploring how research can move the AT field in new directions. The theme of this issue is consistent with the editors’ goal that ATOB promotes effective knowledge transfer, highlighting new information on the outcomes and benefits of AT for persons with disabilities. Across the three articles, we see specific examples of how research can influence the AT industry. Extant research, in this case about BCI, can find new applications when shared with those in the AAC field. Findings from the study Michels conducted inform how AT policy is—and should be—developed within school districts, an especially topical issue given the ever-wider relevance of all kinds of technology to assistive functions. The essential role of stakeholder input in product research and development is highlighted in the value Microsoft places upon the AURC.

The exponential growth of technology in virtually all lives across the globe testifies to the crucial role that the Assistive Technology Industry Association (ATIA) itself plays. Given its broad mission, ATIA strongly supports a wide and diverse set of voices and perspectives in the research it seeks to put before the readers of its journal. Toward that end, please be reminded of its open access policy.

Consider whether you, too, have a role to play in ATOB:

- The journal has open positions available for peer reviewers.
- All readers are invited to share the link to this issue on their social media networks.
- ATOB invites contributions from industry representatives and practitioners, including those who have disabilities, not only researchers.

We all share a common goal of realizing the full potential of AT to improve lives. Echoing our title, let's work together to realize a broad array of AT's "outcomes and benefits."

## Declarations

This content is solely the responsibility of the authors 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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# Considering Augmentative and Alternative Communication Research for Brain-Computer Interface Practice

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## Abstract

***Purpose:*** Brain-computer interfaces (BCIs) aim to provide access to augmentative and alternative communication (AAC) devices via brain activity alone. However, while BCI technology is expanding in the laboratory setting, there is minimal incorporation into clinical practice. Building upon established AAC research and clinical best practices may aid the clinical translation of BCI practice, allowing advancements in both fields to be fully leveraged.

***Method:*** A multidisciplinary team developed considerations for how BCI products, practice, and policy may build upon existing AAC research, based upon published reports of existing AAC and BCI procedures.

***Outcomes/Benefits:*** Within each consideration, a review of BCI research is provided, along with considerations regarding how BCI procedures may build upon existing AAC methods. The consistent use of clinical/research procedures across disciplines can help facilitate collaborative efforts, engaging a range of individuals within the AAC community in the transition of BCI into clinical practice.

***Keywords:*** brain-computer interface, augmentative and alternative communication, clinical, translation.

# Considering Augmentative and Alternative Communication Research for Brain-Computer Interface Practice

Since the early 1970s, research on providing access to augmentative and alternative communication (AAC) devices for those with severe physical impairment has grown dramatically with an expanded reach for considering an increasing number of individuals from diverse cultural and linguistic backgrounds, advocating for AAC acceptance, and utilizing an expanding array of devices for AAC access (Hourcade, Everhart Pilotte, West, & Parette, 2004; Light & McNaughton, 2012). One area of focus is the provision of AAC control via brain-computer interface (BCI) technology, which does not require any overt behavior. BCIs for accessing AAC provide communication device control by recording brain signals associated with attention (e.g., the P300 event-related potential and steady state visually evoked potential) and attempted or imagined motor control (e.g., sensorimotor modulations), via electroencephalography (Brumberg, Pitt, Mantie-Kozlowski, & Burnison, 2018). Unlike conventional AAC access methods such as switch access and eye gaze, the BCI link between an individual's neurological activity and AAC device eliminates the need for a person to possess any form of reliable physical movement to access communication. Therefore, BCI technology has the potential to unlock communication for adults and children with the most advanced physical impairments due to neurological diseases and disorders such as amyotrophic lateral sclerosis (ALS), locked in syndrome, and cerebral palsy (Fager, Beukelman, Fried-Oken, Jakobs, & Baker, 2012).

Initial investigations show individuals with severe physical impairments are positive about the potential applications of BCI techniques (Blain-Moraes, Schaff, Gruis, Huggins & Wren, 2012). For instance, a focus group including eight individuals with ALS revealed that while participants noted barriers to BCI use, such as fatigue and discomfort, they found BCI technology offered freedom, hope, and connection, filling an unmet need in their daily lives (Blain-Moraes et al., 2012). However, even in light of this positive view of BCI technology, and promising results from long-term in-home trials (e.g., Wolpaw et al., 2018; Holz, Botrel, Kaufmann, & Kübler, 2015; Miralles et al., 2015), BCIs are still primarily restricted to laboratory settings, and there is limited interest from AAC professionals and commercial partners (Nijboer, 2015; Chavarriaga, Fried-Oken, Kleih, Lotte, & Scherer, 2017). This limitation is, in part, due to continued problems associated with BCI reliability (e.g., Vansteensel, Kristo, Aarnoutse, & Ramsey, 2017) and set up requirements (e.g., Blain-Moraes et al., 2012, Zickler et al., 2011). However, a general lack of consistency between AAC research and BCI procedures may further impede the effective translation of BCI technology into clinical practice.

The field of AAC as a whole seeks to provide person-centered communication access to individuals with complex communication needs that support an individual's strengths, autonomy, social interactions, activities of daily living, and unique desires, along with their family and caregivers (e.g., Light & McNaughton, 2013; Blackstone, Williams, & Wilkins, 2007). These person-centered frameworks encourage stakeholder involvement in the assessment and intervention process, facilitating communication device success (Pitt & Brumberg, 2018a; Gosnell, Costello, & Shane, 2011; Johnson, Inglebret, Jones, & Ray, 2006). Although the foundation exists for considering BCIs in the context of AAC (e.g., Pitt & Brumberg, 2018a), current BCI practice does not fully utilize existing AAC frameworks. For instance, BCI research primarily focuses on the development of spelling-based devices for adults with acquired neuromotor disorders (see Rezeika et al., 2018 for review), which leaves children, and others with limited literacy, as an understudied and underserved population. In addition, current practices tend to focus on the assessment of one or two BCI devices, instead of across the full range of possible BCI types, which may limit appropriate matching of BCI technology to individual strengths and needs (cf. Pitt & Brumberg, 2018a). As BCI technology continues to mature, incorporation of established AAC research and clinical best practices are needed to ensure advances in both fields are fully leveraged. Using an AAC perspective for BCI research will help development of effective person-centered BCI products, policies, and practices. This manuscript will outline different considerations for future BCI research, which all build upon established clinical AAC practices with the goal of encouraging multidisciplinary collaborations between researchers and professionals from both BCI and AAC and assisting the translation of BCI technology into clinical settings.

## Target Audience and Relevance

The topics outlined in this paper aim to inform multidisciplinary AAC professionals about pertinent AAC and BCI developments to encourage a variety of disciplines in both the public and private sectors to engage in the translation of BCIs for AAC access into clinical practice. In addition, BCI researchers can benefit from the following discussion by using AAC perspectives and research outcomes to advance the development and implementation of BCI technology from existing AAC practices.

## Methods

A multidisciplinary team including two speech-language pathologists, and one BCI engineer, with combined experience in BCI, AAC, and individuals with complex communication needs identified six major topics of consideration important for BCI products (including access to commercial AAC devices, and supporting children and individuals with impaired or emerging literacy skills), practice (i.e., person-centered assessment, outcomes, and developing engaging and supportive training practices), and policy (i.e., consistency with American Speech-Language Hearing Association (ASHA) policies for AAC practice), based upon published reports of AAC and BCI developments. Within each of the following sections, we first briefly review current BCI advancements, and following, outline different considerations for BCI products, practices and policies to build upon existing AAC methods.

### *AAC Considerations for the Development of BCI Products and BCI Access to Commercial AAC Devices*

To date, the primary focus of BCI development is to provide access to spelling-based communication for adults with acquired neuromotor disorders. A large variety of BCI systems are currently in development, which most commonly rely on brain signals including the P300 event related potential (e.g., Donchin, Spencer & Vijesinghe, 2000), steady state visually evoked potential (e.g., Sutter, 1992) and motor (imagery) modulations of the sensorimotor rhythm (e.g., Blankertz et al., 2006). These target brain-signals are recorded by non-invasive electroencephalography, in which brain activity is recorded on the surface of the scalp using electrodes that are placed in a fabric cap (similar to a swimming cap).

P300 and steady state visually evoked potential-based BCI devices are controlled using selective attention to presented items (Brumberg, Pitt, Mantie-Kozlowski, & Burnison, 2018). P300-based BCI displays often utilize a grid layout containing letters, symbols, and numbers (e.g., Donchin et al., 2000). To make a selection, the individual attends to the target communication item they wish to select, while all items within the grid are randomly flashed. Approximately 300ms after the target stimulus is flashed, a positive voltage is detectable in the electroencephalography recordings in comparison to the other non-target stimuli (Donchin et al., 2000). The BCI algorithm then selects the item that is associated with this P300 event. For steady state visually evoked potential access, the BCI display contains multiple stimuli all flickering at different frequencies (e.g., 5-15Hz). The BCI algorithm is able to identify and select the attended item using posterior scalp recordings, which will have the greatest amplitude (Müller-Putz, Scherer, Brauneis, & Pfurtscheller, 2005) and temporal correlation (Lin, Zhang, Wu, & Gao, 2006) for the attended strobe frequency in comparison to non-attended items. Finally, motor (imagery) devices are controlled via imagined movements (i.e., mental rehearsal of an action without physical execution). Imagery tasks, along with actual or attempted movements, are detectable by the BCI through modulation of the sensorimotor rhythm, which is an electroencephalography signal occurring in the mu (8-12 Hz) and beta (15-25 Hz) frequency bands over sensorimotor scalp locations. Motor (imagery) tasks decrease the power of the sensorimotor rhythm in comparison to rest (Brumberg, Pitt, Mantie-Kozlowski, & Burnison, 2018), leading to BCI output. Modulation of the sensorimotor rhythm can be interpreted by the BCI continuously, such as a left-hand imagery moving an onscreen mouse cursor to the left (e.g., Wolpaw & McFarland, 2004; Brumberg, Pitt & Burnison, 2018), or discretely, such as switch type access (Friedrich et al., 2009; Brumberg, Burnison, & Pitt, 2016; Scherer et al., 2015). A full review of BCI methods including both auditory and visual techniques can be found in Brumberg, Pitt, Mantie-Kozlowski, and Burnison (2018), and Akcakaya et al., (2014).

Most often, BCIs are designed with lab-specific displays, presentation paradigms, and software that may or may not be designed from a person-centered approach, in contrast with commercially available AAC device designs that are based upon a history of person-centered considerations (Romich, 1993). Thus, although early efforts are being made to utilize BCI methods to access commercial AAC paradigms (e.g., Thompson, Gruis & Huggins, 2013; Scherer et al., 2015; Brumberg et al., 2016) and assistive technology software (QualiWorld, QualiLife Inc. Paradiso-Lugano, CH; e.g., Zickler et al., 2011), a heightened focus on utilizing commercially available technology may promote collaborations with commercial partners and manufacturers to help navigate barriers to funding (Ray, 2015).

The BCI development process should incorporate feedback from individuals who may use BCI to ensure BCI technology meets their unique needs (Nijboer, 2015). Currently, studies exploring the specific desires of individuals with complex communication needs are still emerging (e.g., Blain-Moraes et al., 2012; Liberati et al., 2015). For instance, findings by Liberati et al. (2015) reveal that individuals with ALS highly value devices that can adapt to one's changing sensory-cognitive-motor profile and exploit the strongest current communication channel both in the short (e.g., within one day) and long term. The incorporation of commercial AAC technology into BCI development increases device modularity, by allowing individuals to continue accessing their existing AAC device using BCI as a new access method only. Importantly, device continuity across the disease course may also decrease learning demands and the emotional struggle individuals experience when learning a new assistive technology (Liberati et al., 2015) and brings BCI development in line with current AAC practices for establishing multimodal access to commercial communication devices (e.g., eye gaze plus switch; see Fager, 2018 for a review). These considerations in total provide individuals with the freedom to alter their access method throughout the day depending upon their preference, environment, and level of fatigue (Brumberg, Pitt, Mantie-Kozlowski, & Burnison, 2018).

### *Supporting Children and Individuals with Impaired or Emerging Literacy Skills*

The focus of traditional BCI development on adults with acquired neuromotor disorders (e.g., Moghimi, Kushki, Guerguerian, & Chau, 2013) is primarily due to difficulty studying pediatric neurophysiology such as sensory sensitivity, the developing brain, and the limited amount of neurotypical data available (Huggins et al., 2017). However, restricting BCI use to adults limits the potential applications of BCI, especially for those with impaired or emerging literacy skills, and fails to account for the potential impacts of early AAC intervention across a child's lifespan. Incorporating the perspectives of children in BCI research, design, and development is equally as important as adults, as both groups have different communication wants and needs (Light, Page, Curran, & Pitkin, 2007). When asked to design communication supports, children emphasized the importance of device personalization (e.g., colors, shapes, access technique), and incorporated multiple functions beyond speech such as play, artistic expression, social interaction, and companionship to promoting meaningful communication (Light et al., 2007). In addition, effective AAC implementation for children must provide developmentally appropriate access to language and literacy and facilitate participation in educational opportunities (Light & Drager, 2007). Therefore, how to best support children's development and meaningful interactions in their various social and educational environments with both neurotypical peers and those who use AAC is an important consideration for child-centered AAC and BCI success (Ibrahim, Vasalou, & Clarke, 2018).

Current BCI techniques may be adapted for accessing communication utilizing pictorial symbols as a first step toward the provision of BCI access to AAC for children (Brumberg, Pitt, Mantie-Kozlowski, & Burnison, 2018). Though BCI translation in this domain is still in the early stages (e.g., Ahani et al., 2014; Scherer et al., 2015; Brumberg et al., 2016), there is an established history of AAC interface research and development that provides for the cognitive, linguistic, sensory, and communication needs of children. Further, AAC professionals consider an array of factors when designing communication device displays to meet the needs of children who use AAC (Thistle & Wilkinson, 2015), including icon color and contrast (Wilkinson & Jagaroo, 2004), placement and size (Beukelman & Mirenda, 2013), texture and shape (Scally, 2001), and motion (Jagaroo & Wilkinson, 2008).

In addition, commercial AAC devices have historically focused on grid-based graphical layouts (Wilkinson & Jagaroo, 2004), as have many BCIs including the popular P300 speller (e.g., Donchin et al., 2000) in which individual symbols/letters are selected from a decontextualized arrangement. However, AAC research has begun to explore visual scenes as an alternative to grid layouts, which are based on context rich images (e.g., photographs) that depict events, activities, and individuals significant to the person using the AAC device. In this manner, the visual scene environment is used to display items and symbols for selection (e.g., the individual may select their favorite toy from an image of their toy chest) that, once selected, can produce communication output (Dietz, McKelvey, & Beukelman, 2006; Wilkinson, Light, & Drager, 2012). Visual scene displays are currently available in many commercial AAC devices, with studies showing the utility of these displays in supporting both adults and children with complex communication needs (see Wilkinson & Jagaroo, 2004; Wilkinson et al., 2012 for a full review). The concept of utilizing BCI techniques to provide AAC access to visual scene displays is an interesting consideration in BCI development. The contextual nature of visual scene images means items within the scene, by nature, may differ from each other in relation to size, shape, color, and orientation, which all may impact the quality of signals used for BCI control. In addition, how items within the visual scene display are highlighted / selected during scanning (e.g., bold outline, motion) influences visual scene outcomes (McCarthy & Boster, 2017). Similarly, P300 grid stimulus patterns are known to affect P300 signal quality (Akcakaya et al., 2014), and it is possible stimulus presentation using visual scenes will also affect target BCI signals.

It is important to note, however, that design considerations go beyond just the graphical interface. Below, we outline additional feature matching considerations for AAC and BCI assessment in more detail. However, it should be mentioned that special considerations are necessary to decrease a child's learning demands and support his or her developing language, literacy, learning, and growth trajectory, in addition to changing needs, skills, and preferences (Light & Drager, 2007). Congenital motor impairment may further complicate feature matching guidelines due to the possibility of impaired first-person motor imagery skills (recreating the sensations associated with the performance of a physical action; Olsson & Nyberg, 2010), which are important for successful motor imagery-based BCI outcomes (Neuper, Scherer, Reiner, & Pfurtscheller, 2005; Vuckovic, & Osuagwu, 2013). Finally, design aesthetics are an important consideration for both adults (Blain-Moraes et al., 2012; Nijboer, 2015) and children. However, children are more likely to engage in the use of technologies that they find appealing, cool, and bolster their social image (Light & Drager, 2007).

## AAC Considerations for BCI Practice

### *Person-Centered Assessment*

Feature matching is the established best practice for AAC intervention and includes individualized assessments, which seek to match an individual to a specific AAC device and page-set based upon factors such as their current and future sensory, motor, cognitive, and linguistic profile, in addition to their environment, communication needs, and levels of support (Pitt & Brumberg, 2018a; Gosnell et al., 2011; Beukelman & Mirenda, 2013). These person-centered procedures allow an individual to trial multiple AAC devices with a variety of access methods, feedback types, and graphical interfaces. This ultimately leads to the selection of an AAC device that best matches each individual's unique strengths and preferences and facilitates AAC success while limiting the potential for device abandonment (Beukelman & Mirenda, 2013). Application of the feature matching framework is important for the transition of BCI into clinical practice (e.g., Hill, Kovacs & Shin, 2015), especially given the range of profiles of adults and children with complex communication needs who may use BCI and the diversity of BCI devices (e.g., Brumberg, Pitt, Mantie-Kozlowski, & Burnison, 2018). Specifically, each BCI method may differently support an individual's unique sensory-cognitive, motor, and motor imagery strengths (Pitt & Brumberg, 2018a), with each individual having a unique BCI preference (Peters, Mooney, Oken, & Fried-Oken, 2016).

Identifying predictors for BCI performance is a growing area of BCI research and is critical for understanding how person-centered factors such as motivation (e.g., Nijboer, Birbaumer, & Kübler, 2010), attention (e.g., Riccio et al., 2013), and motor imagery skills (e.g., Vuckovic, & Osuagwu, 2013) influence BCI success. However, while feature matching-based assessment protocols aiming to inform BCI trials are in early development (Pitt & Brumberg, 2018b), existing research typically focus on predicting performance for only one or two types of BCI rather than across a full range of techniques, as is the case with clinical AAC assessment. The shortcomings of focusing on so few potential BCIs means that individuals who may need BCI for communication may not be matched to the most appropriate device that meets both individual needs and preferences. However, the foundational efforts for BCI assessment have resulted in positive outcomes and point to the need for additional studies investigating how person-centered factors influence BCI performance across a full range of devices, eventually leading to multiple BCI device trials for establishing individual preferences. In addition, as potential stakeholders may not be aware of BCI tools (Vansteensel, et al., 2017), future efforts should explore how BCI fits into existing AAC frameworks in order to lower barriers for speech-language pathologists, and other AAC specialists, to learn and incorporate BCIs into clinical AAC practices. Recognizing that BCI can be considered as an access technique for AAC can help facilitate adoption of BCI approaches into clinical and commercial AAC.

Feature matching also considers display design for determining preference and appropriateness of AAC selections and has specific importance for BCIs. For instance, traditional P300 grid paradigms highlight all items within the graphical display by toggling between grey (or a dark color) and white (e.g., Donchin et al., 2000). However, recent BCI research is also exploring other stimulation patterns such as the use of faces and non-face stimuli for identifying the current communication item (e.g., toggling between the communication item and a human face or shape). However, while non-face stimuli have only been evaluated for use by neurotypical adults (e.g., Kellicut-Jones, & Sellers, 2018), faces may increase BCI outcomes for individuals with ALS (Kaufmann et al., 2013; Geronimo, & Simmons, 2017). Similar to current AAC practice, it is clear these and other interface characteristics such as matrix size and interstimulus interval (e.g., Sellers, Krusienski, McFarland, Vaughan, & Wolpaw, 2006), flash rate (McFarland, Sarnacki, Townsend, Vaughan, & Wolpaw, 2011), symbol size, color (e.g., Salvaris & Sepulveda, 2009), and motion (e.g., Guo, Hong, Gao, & Gao, 2008) should be included into future BCI feature matching procedures, though their specific importance for individual outcomes are still emerging. The role of caregivers is also an important consideration in any feature matching framework, especially for BCI, due to factors associated with BCI set up (e.g., correct placement of electroencephalography cap, application of electrolyte gel) and potentially lengthy training times (Pitt & Brumberg, 2018a). Therefore, efforts to include caregivers in the BCI process is a critical step in the application of BCI in clinical practice (Wolpaw et al., 2018).

### *Person-Centered Outcomes*

To date, BCI research focuses on outcomes relating to speed and accuracy in order to validate the complex algorithms used for translating brain activity into computer control. While initially important for developing reliable BCI systems, a broader focus is now needed on personalized BCI outcomes (Nijboer, 2015). Drawing from conventional AAC research, speed and accuracy are still relevant (e.g., Brumberg, Pitt, Mantie-Kozlowski, & Burnison, 2018), in addition to person-centered AAC outcomes including functional skills (e.g., initiating interactions, repairing communication breakdowns, engaging in social conversations), and quality of life (e.g., their ability to participate in various preferred environments) (Beukelman & Mirenda, 2013; Hill et al., 2015).

The World Health Organization's International Classification of Functioning (ICF) Disability and Health framework, developed by a multidisciplinary and multicultural group of experts, emphasizes daily activities and participation during assessment of an individual's function and disability (Andresen, Fried-Oken, Peters, & Patrick, 2016; Hill et al., 2015; ; Moghimi et al., 2013), and is well suited to AAC assessment (Fried-Oken & Granlund, 2012). However, the use of this framework for BCI is still in the early stages, with recent work by Andresen et al. (2016), aiming to map a range of BCI assessment tools onto the ICF structure. In addition, Andresen and colleagues included individuals with neuromotor disorders in the research team, helping identify important constructs beyond those presented by the ICF, including quality of life, and the function, design, and support of assistive technology. Previous work also examined BCI outcomes in relation to user centered design (effectiveness, efficiency, satisfaction, and use in daily life; Kübler et al., 2014); however, there is currently a lack of standardized procedures for evaluating BCI outcomes, which limits scientific discussion, and understanding individual differences in BCI outcomes (Chavarriaga et al., 2017).

### *Developing Engaging and Supportive Training Practices*

As with traditional AAC techniques, BCI control is a learned skill, and the field is currently investigating a range of paradigms to provide meaningful BCI instruction, feedback, and tasks during BCI training protocols, including virtual reality (Lotte et al., 2012), real-time feedback of brain activity (Hwang, Kwon, & Im, 2009), increasing task complexity (McFarland, Sarnacki, & Wolpaw, 2010), using meaningful auditory and visual feedback (Brumberg, Pitt & Burnison, 2018), along with allowing for free exploration of BCI control strategies (e.g., Neuper, Müller, Kübler, Birbaumer, & Pfurtscheller, 2003), and identifying strategies that may support BCI success such as goal oriented tasks (e.g., imagining reaching for a cup, Vuckovic & Osuagwu, 2013), familiar imagined actions (Pitt & Brumberg 2018b) and novel imagined actions (Halder et al., 2011). See Lotte, Larrue, & Mühl, 2013, and Lotte & Jeunet, 2015, for a full review. However, best practices for BCI learning are still unknown, though there is agreement that traditional BCI training approaches are suboptimal (Jeunet, Jahanpour, & Lotte, 2016; Chavarriaga et al., 2017) and focus too heavily on machine learning rather than the individual (Lotte et al., 2013). In addition, current BCI training paradigms often provide unimodal feedback that is too simplistic for individuals to understand how to improve their performance. For instance, during motor imagery BCI control tasks, individuals may only receive feedback regarding whether task completion was correct/incorrect, or a visual graphic (e.g., bar or cursor) that fluctuates in proportion to the power of the sensorimotor signal used for motor imagery BCI control (Jeunet, et al., 2016; Chavarriaga et al., 2017), both of which are difficult to use for online modification of BCI control. Taken together, these training methods do not fully consider the unique individual, or follow learning principles utilized by other disciplines, which may impede BCI mastery (Lotte, et al., 2013, and Lotte & Jeunet, 2015).

While there are hurdles specifically associated with BCI training due to the nature of individuals' specific neurological and physical impairments, and an inability for communication partners to access the BCI system, existing AAC training approaches may aid development of BCI practices for guiding adults and children toward BCI mastery. AAC instruction is designed to account for the varied abilities, learning preferences, and priorities of individuals with complex communication needs with the aim of meeting the individual's personal goals, strengthening relationships, and furthering societal participation (Blackstone, et al., 2007). Individuals who use AAC may wish to utilize a range of learning supports such as print materials, drill and practice, and online tutorials. However, the method or combination of methods preferred by the individual is likely to change depending upon factors such as their age, levels of skill, and motivation (Rackensperger, Krezman, McNaughton, Williams, & D'silva, 2005). Consideration of all methods accessible to individuals who use BCI along with preferences and priorities may enhance BCI learning.

Drill-based explicit instruction and aided input are commonly employed techniques in promoting AAC success (Beukelman & Mirenda, 2013), with ongoing services provided by a skilled professional (Hill et al., 2015). Scaffolding techniques accompany these standard procedures, providing varying levels of assistance to facilitate task success and ultimately independence (Light, McNaughton, Weyer, Karg, 2008). During aided instruction, the communication facilitator provides multimodal input by modeling access to the communication display (e.g., by pointing) while communicating verbally, ideally throughout the day (e.g., Beukelman & Mirenda, 2013). In many scenarios, this technique requires that the communication partner can access the AAC system, which may pose a unique challenge for application to BCI. However, modeling and scaffolding used for eye-gaze and head-pointer access techniques may be informative for developing strategies for supporting BCI. For instance, a clinician may place their own head next to a client's while using a head-pointer to demonstrate the relationship between head movements and pointer effects. A similar approach could be adapted for BCIs with clinician support. Specifically, communication facilitators can use their own head mounted laser pointer to model where they are directing their attention in order to improve training and outcomes for attention modulated BCIs modeling an overt attention strategies known to increase BCI performance (Brumberg, Nguyen, Pitt, & Lorenz, 2018; Brunner et al., 2010; Peters et al., 2018).

Another barrier to BCI training is that traditional methods are generally sterile, and boring for participants (Chavarriaga et al., 2017). In contrast, conventional AAC training methods incorporate incidental teaching strategies that provide individuals the opportunity to practice AAC control within meaningful everyday activities (Beukelman & Mirenda, 2013; Light et al., 2008). Focusing on functional communication is important for engaging individuals to learn AAC control, boost self-confidence, and ultimately support access and participation in meaningful activities, social interactions, and societal roles (Blackstone et al., 2007; Rackensperger et al., 2005). In addition, engaging the attention of children while using BCI can be especially challenging, possibly requiring game-based applications and rewards (Huggins et al., 2017). Current AAC practices emphasize engaging children in AAC activities, with commercial software applications such as Look to Learn (SmartBox Assistive Technology Inc., PA, USA) providing a range of fun activities to foster eye gaze access mastery. In a BCI context, these established foundations from the AAC community may be built upon for engaging individuals in BCI learning paradigms by providing BCI access to motivating activities such as: select the animal (e.g., Vansteensel et al., 2016), select the face to throw a pie (SmartBox Assistive Technology Inc., PA, USA), or allowing an individual with severe motor impairment to interact with their environment during goal oriented tasks (e.g. request and receive/interact with a preferred object or environment), with additional opportunities using virtual or augmented reality techniques (Boster & McCarthy, 2017).

Finally, timely/early intervention is an important consideration in current AAC practice to support communication success and device acceptance by permitting time for skill learning, gradual device acclimatization, stakeholder education, and the provision of skilled interventions (e.g., Ball et al., 2010). Unfortunately, the effects of early intervention are unknown for BCI. However, since BCI can be considered as an access method to AAC, it is feasible that beginning BCI intervention early in the disease course may lead to improved outcomes for both motor imagery and attention modulated BCI systems (Marchetti & Priftis, 2015) in comparison to implementing BCI as a last resort option.

## Considering ASHA Policies for AAC Practice

The considerations described in this paper have the potential to aid the field of BCI move toward consistency with ASHA policies for AAC practice (e.g., ASHA 1992; 2004) that emphasize person-centered factors such as: the use of meaningful, natural, and interactive/social contexts; ecological validity of assessment and intervention methods; comprehensively evaluating, respecting, and supporting the individual's unique sensory-cognitive-motor-language profile and cultural-linguistic diversity; and providing access to a range of AAC systems/methods. In addition, it is crucial to incorporate a range of individuals (AAC professionals, commercial partners, educators, employers, and those who may use AAC in addition to those whom they interact with daily) in the AAC process to ensure the communication rights of an individual are upheld (ASHA, 1992). Understanding how to best provide for caregivers and AAC professionals during the at home implementations of BCI technology is still in the early stages (Wolpaw et al., 2018; Miralles et al., 2015). Therefore, future progress will depend on working collaboratively to develop best practices for AAC and BCI to promote the successful engagement of the AAC community in the intervention process and improve communication support, and outcomes for both fields. In addition, AAC and BCI researchers should remain cognizant that their work may impact health insurance policies regarding AAC device coverage (Romski & Sevcik, 2018). Currently, BCI research may classify individuals with decreased BCI performances as BCI illiterate; however, the performance criteria for this classification is inconsistent and largely unjustified (Thompson, 2018). While understanding how individuals respond differently to varying BCI techniques will help inform the development of BCI assessment guidelines, consideration needs to be given to the term BCI illiteracy, and how BCI competency is described and established. This is necessary to help ensure individuals are not blocked from all forms of BCI provision, as decreased performance with one BCI technique (e.g., P300) does not necessarily mean decreased performance across all BCI techniques. Furthermore, providing an individual with a consistent form of communication, even with decreased accuracy, is better than no communication at all. In this regard, future BCI research may benefit from existing AAC frameworks supported by ASHA, which seek to provide a multidisciplinary construct for defining AAC communication competency in terms of operational, social, linguistic, strategic, and psychosocial (e.g., motivation, attitude, confidence, and resilience) factors (Light & McNaughton, 2014; ASHA, 2018).

## Outcomes and Benefits

BCI technology may provide individuals with severe physical impairment hope and a way to feel unlocked (Blain-Moraes et al., 2012); however, many barriers must be overcome for BCI to be fully incorporated into clinical settings. These hurdles include traditional factors such as the reliability of BCI technology, set-up requirements (e.g., Vansteensel, et al., 2017) imperfect processing algorithms (Lotte et al., 2013), limited sample sizes, and a bias to publishing only positive results (Chavarriaga, 2017). However, while overcoming barriers in these areas is important, a focus solely on the technical aspects of BCI separately from the larger clinical picture of existing AAC developments, policies, and frameworks for which BCI aims to be a part, may ultimately hinder the effective transition of BCI technology into clinical practice.

This paper discussed different considerations regarding how current and future BCI products, policies and practices can build upon existing AAC developments, aiding the clinical translation of BCI technology. For instance, current BCI practice focuses on a small range of potential individuals who may use BCI (e.g., those with ALS, locked-in syndrome), potentially limiting interest in BCI technology from commercial partners (Nijboer, 2015), and the engagement from other AAC professionals. The consistent use of research procedures across disciplines can promote collaborative efforts and teamwork, helping open BCI access techniques to a larger range of individuals who may utilize AAC, by considering BCI as simply another access method within existing AAC frameworks, instead of a fringe technology of last resort for adults with the severest forms of physical impairment.

## Declarations

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# School Technology: Moving Beyond Assistive

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## Abstract

There currently exists within the public education arena a background of political and educational change forces impacting and even threatening the role of educational organizations and services, including assistive technology supports. Issues specifically impacting the role of assistive technology personnel and departments within public education settings include the expanding and changing technology needs of students, the ubiquitous nature of technology now in most classrooms, definitional challenges to technology services, and changing educational initiatives. These factors, combined with the already tumultuous nature of public education and educational structures such as Educational Service Agencies, make it necessary to redefine the role of assistive technology in public education. Research into the changing role of assistive technology within public education structures reveals that there is a need to move assistive technology departments and services away from a focus on referral-based deficit models for individual student remediation to a framework that includes the roles of thought leaders, partners in programming, and experts in technology.

***Keywords:*** assistive technology, educational service agencies, public education, role of assistive technology

## Introduction

This article examines the roles assistive technology (AT) departments and services play within currently shifting public education environments. These roles are explored through the context of Educational Service Agencies (ESAs), such as special education cooperatives, in particular with correlation to all public education structures and settings. ESAs were originally designed to support special education populations in identified school districts. They were linked first to local and state identified needs related to special education populations, and later to state and federal mandates regarding the provision of special education services. AT services have formally been a part of the public education system in some manner since 1990 with the federal mandates of No Child Left Behind, and most ESAs have AT departments. While educational change forces and initiatives have been forcing change upon existing AT structures, this impact is felt even more dramatically within the arena of ESAs such as special education cooperatives. ESAs exist in a current educational environment where language around accountability and value-added services is beginning to mirror a business model with a focus on profit and customer satisfaction as much as an educational model with a focus on educating students. This business focus increases the need to sharpen the effectiveness of all departments, including AT. Emerging service models, blurring lines between assistive and instructional technology, and decreased reliance upon ESAs are some of the external forces impacting AT departments. This paper addresses the question: What is the role of assistive technology departments in public education structures such as ESAs?

## Target Audience and Relevance

This work is relevant to administrators in all public education systems including ESAs as it provides a research-based framework for re-structuring AT departments and services to meet student needs in alignment with changing educational environments. It is also relevant to AT practitioners within all public education arenas as it clarifies the various change forces that are leading the way for new structures and new service delivery models. While there is a specific reference to the role of AT departments within ESAs, the information generalizes to all public education environments and structures.

## Literature Review

### *Educational Service Agencies (ESAs)*

States have a mixed history of proactive forward motion regarding education for students with special needs. While many early state mandates were not fully inclusive or well-funded, they did lead the way for progressive thought around education and special needs (Gittens, 1994). To fulfill the state mandates with limited funding, facilities, and personnel, school districts began to band together to share resources. Many of these groupings were state-designed and funded, but several individual groupings were also formed through joint agreements from invested school districts. Through the years, these sharing arrangements have become more and less formalized and have had a variety of structural and administrative arrangements. Stephens and Keane refer to these types of shared resources agreements as Educational Service Agencies (ESAs) (2005).

This paper will continue to use the broader term of "ESA" with the understanding that the specific type of ESA discussed is a special education cooperative.

Stephens and Keane (2005) identify four stages ESAs have gone through since their inception, with the current or fourth stage of Restructuring marked by increased oversight and accountability. However, this author proposes that there currently exists within the educational and ESA environment a time of change that is significant enough to state that ESAs are not only approaching, but are securely within a fifth stage of development. The tumultuous nature of the educational and political environments in public education indicates that ESAs have moved far beyond the calm and deliberate stages of Restructuring. According to Harmon, Keane, Leddick, Stephens and Talbot (2012), ESAs are currently facing overwhelming challenges to their existence. Given this background, this author proposes that ESAs are in a developmental stage that calls for the need to evolve, rather than adapt (Restructure). While both words have a connotation of being new or different, it is evolution that depicts a forward trajectory – moving not only to a new form, but to one of advancement. It is further proposed that ESAs are in a position that is serious enough to label this fifth stage one of Evolution or Dissolution. This trajectory further increases the pressure on departments within ESAs, including AT departments, to change current practices. This significant period of change for ESAs is precipitated by the atmosphere of change that is mirrored within the general education arena. It is apparent that this potential final stage of ESAs is brought about in part by the changes facing all public education settings in general.

The intent of this paper is not to redesign the core functions of ESAs or public education, but to provide an understanding of the background and environmental considerations that are the formative features and current influences on ESAs and their services, specifically that of AT departments. AT departments and services are struggling to find their role in this arena of challenge, confusion, and turmoil around public education.

### *Assistive Technology*

Assistive technology legislation initiated from the 1988 Technology-Related Assistance for Individuals with Disabilities Act, also known as the Tech Act (Public Law [PL] 100-407) (Bausch, Mittler, Hasselbring, & Cross, 2005). Interestingly, this legislation was not specific to public education but was intended for individuals of all ages in the general population. The Tech Act not only defined AT but also provided some funding for training, equipment, and services (University at Buffalo, 2005; Bausch, et. al., 2005). In 1998, the Tech Act was amended with the Assistive Technology Act, which further extended states' funding for AT. The language in this amendment was again specific to all Americans with disabilities, and not specific to the public school sector.

Special education law is rooted in the 1975 Education for All Handicapped Children Act (PL 94-142) which, when reauthorized in 1990, became the Individuals with Disabilities Education Act (IDEA) (PL 101-476). It is within IDEA that AT was federally mandated to become part of the special education system through the Individual Education Program (IEP) process. IDEA firmly placed the mandate of the

Tech Act in public schools. The 1997 IDEA amendment (PL 105-17) further defined and solidified AT as part of a free and appropriate public education (University at Buffalo, 2005). The amendment linked AT tightly to special education by requiring that AT be considered when a student's Individualized Education Program (IEP) is developed (Legal Information Institute, 1992). The services captured in the mandate included student evaluation, equipment procurement and maintenance, teaming, and training students, families and professionals (Legal Information Institute, 1992).

It is important to understand this background of legal language defining AT in the educational system as we move toward understanding the confusion inherent in the changing roles and blurred lines around AT in public education. The factors impacting the role of AT service and support in education include the expanding and changing student population receiving AT services, the increasingly ubiquitous nature of technology in classrooms, challenges to the definition of what constitutes AT, and changing educational initiatives.

*Expanding student population receiving AT services.* A particular challenge to the clarity around the definition of AT and AT services resides in the evolving student body receiving AT services. At the inception of AT services in schools, many students receiving services were categorized as students with "low incidence" disabilities, comprising a small percentage of the student population and having moderate or severe needs (Edyburn, 2000). ESAs and their service departments were initially formed to meet the higher needs in this student population. In recent years, a different and growing population of students has been identified as potential AT users. This group of students, categorized as students with "high incidence" disabilities comprises a larger percentage of district students and has mild to moderate disabilities.

This expanding and changing student population challenges the perception of what constitutes AT devices and challenges the model for providing AT supports and services. AT devices are most commonly thought of as some type of computer or electronic device. For students with moderate to severe disabilities, that might be closer to actuality. However, for students with mild disabilities, the true range and definition of AT devices is much wider. AT devices exist upon a continuum of low to high technology and encompass items from the low end of the technology continuum such as pencil grips or slant boards to more complex high end technology items such as eye gaze technology (Reed, 2004). Districts and AT personnel who are not cognizant with the entire scope of AT struggle to meet the demands of this larger population. They often look to a smaller solution pool or provide higher levels of technology than is needed. This over-matching of technology to needs leads to increased costs to districts and can limit student independence if technology over-provides support.

To meet the needs of students with more moderate to severe disabilities staff were required to understand significant physical complications and their impacts upon learning, and also understand the then novel technology solutions. The knowledge base needed was so deep and broad that it was difficult to transfer to others. AT service was provided to these students using the expert model, where the AT experts enter into the environment, evaluate the student, determine the best technology to support needs, implement the technology and move on to the next student needing expert support. Edyburn (2000) states that this traditional expert model of completing in-depth evaluations and providing AT support cannot be scaled up to meet the needs of the larger high incidence student population. Therefore, a new service delivery model is needed to provide high quality AT service to this expanding student group.

*The ubiquitous nature of technology in classrooms.* Harmon et. al, (2012) note that the increased prevalence of technology has contributed to the turbulence that ESAs face in their bid to survive and compete. The availability of free electronic content, the on-line service delivery model that negates the need for face-to-face service delivery, and the erasure of geographic boundaries for service are some aspects of technology that challenge the existence of ESAs and also challenge the role of AT departments. Free online content helps widen the field of expertise so anyone can become educated to some level of competency with AT. Online content has also been instrumental in removing the novelty from AT and removing the idea that AT service provision is the sole domain of identified experts. The decreased reliance upon geographic boundaries for service provision increases competition for AT departments whose services are often defined by these geographic school boundaries. AT expertise can now be provided by any knowledgeable individual with access to on-line service delivery systems.

*Challenges to the definition of AT.* The legal definition of AT has stood with few changes since 1988. AT is rooted in special education as a service to students who are identified as having a disability and an IEP or a 504 plan. State publications clearly make this link. The Illinois AT Guidance Manual states that "Assistive Technologies are a classification of technologies that are specific to individuals with disabilities" (Wojcik & Douglas, 2012, p. 5). The Montana Office of Public Instruction provides that "Assistive technology devices are any item, piece of equipment, or product system (software) used to increase, maintain, or improve the functional capabilities of a student with disabilities" (Montana Office of Public Instruction, 2004, p. 7). South Carolina also follows suit with the statement "Assistive technology is any tool that helps students with disabilities do things more quickly or easily or independently" (South Carolina Assistive Technology Program, 2015, p. 1). However, many recent educational initiatives are using technology previously considered to be “assistive” to serve all students.

This new look at technology use has prompted more focus on the difference between AT and instructional technology, as well as the role of the AT professional in serving students. The definitions are further complicated because the same tool can be used as instructive or assistive technology depending upon the student, the identified educational need, and the outcome of the tool upon student performance (Stroud, 2010; Edyburn, 2000). This requires a level of subtlety in linguistic understanding when classifying technology as assistive or instructional, a subtlety in language that may not be readily available to educators not immersed in the field of technology or special education. It is the measure of performance that moves the ubiquitous classroom instructional technology into the realm of assistive technology. Edyburn (2000) states, "When the focus shifts from teaching the skill to emphasizing a functional outcome (performance), the use of technology changes from instructional to assistive" (p. 12). While the subtlety of these definitions can be demonstrated for every piece of technology and with every student's performance both with and without that technology, there are barriers to clarity. First, there is little specific research regarding the efficacy of AT to improve student performance (Parette, Peterson-Karlan, Smith, Gray, & Silver-Pacuilla, 2006). Further, given ever-increasing demands on teachers' time and expertise, there is limited time for individual student and technology scrutiny in a classroom to make the determination around instructional versus assistive for classroom technology.

If the lines between assistive and instructional technology are blurred and there remains limited time, research, or inclination to clearly delineate the definitions in classrooms, why is there a need to provide this clarity? The need is reflected in the link between AT and students with disabilities. If instructional technology crosses into assistive technology and students who are depending upon classroom technology for successful performance do not have a designation under special education, they can lose access to technology when policy or classroom procedures change. Assistive technology remains legally tied to Free and Appropriate Public Education (FAPE) mandates and requires consideration in the accommodation section of IEP paperwork; instructional technology is not tied to federal mandates, nor is it required as part of classroom or educational support.

From the standpoint of evaluating service delivery by AT departments, this is not just a question of semantics. AT personnel find their roles changing in response to new definitions. They are often faced with the dilemma of remaining as AT service and support personnel or expanding their roles to include the larger responsibilities of curriculum planning and lesson development with the inclusion of technology. This happens as districts link AT specialists with all technology and request their service on this larger instructional scale.

*Changing educational initiatives.* Educational initiatives are ever changing and expanding. This also blurs the lines between instructional and assistive technology. Some of these initiatives include universal design for learning (UDL), differentiated instruction, and response to intervention (RtI) (more commonly known as a type of multi-tiered levels of support). The definitions and distinctions have a level of subtlety. Wojcik and Douglas (2012) state that UDL is a means of "reducing barriers that prohibit student learning" while AT "allows individual students to overcome those barriers presented by curricular tasks" (p. 13). UDL is a proactive classroom strategy while AT is an individual student-based response to performance difficulties. The distinction between differentiated instruction and AT is similar. Differentiated instruction is planned proactively to meet individual students' learning needs whereas AT is a reactive approach based upon levels of performance (Wojcik & Douglas, 2012). The relationship between RtI and AT is complicated. Documentation in the Illinois Assistive Technology Guidance Manual is nebulous (Wojcik & Douglas, 2012). It states that technology can be used in the tiers of support but that if technology "significantly alters the way the intervention is implemented, the effectiveness and fidelity of the intervention may also be altered" (Wojcik & Douglas, 2012, p. 14). The manual does advocate including AT tools to support students with disabilities under the RtI framework. However, RtI is a general education initiative and there is no specific language around technology use that might increase performance of students without an identified educational disability.

Expanding and varying student needs, the ubiquitous nature of technology in classrooms, and changing educational initiatives have combined within the already tumultuous public education environment to challenge the role of AT departments. It has become necessary to redesign this role in alignment with current needs. This research attempts to provide a framework for this by addressing the question: What is the role of AT departments in public education structures such as ESAs?

## Method

The authors used a mixed quantitative and qualitative survey instrument to gather data from member districts of an ESA regarding use and perceived benefit of the ESA's assistive technology department and to solicit feedback on potential new programming and services. The ESA is located in a mid- to high-socioeconomic suburban area in the Midwest and serves 18 member districts. The research data was obtained from these member districts as well as the internal ESA AT staff. Quantitative data from the ESA's historical service data was used to analyze service trends by type of service and by professional category (Occupational Therapy [OT], Physical Therapy [PT], Speech and Language Pathologist [SLP], and Educator). Grounded theory was used to help structure the complex environmental contexts that form the background canvas of this question including life stages of ESAs and public education change forces.

## Outcomes and Benefits

### Service Professional and Service Category Data

The ESA AT service category records and service hours for a five-year period were examined for trends. Service categories are the type of services requested by ESA member districts and were used to examine and predict trends around member district service needs and use, overall trends around fee for service hours and fee for service hours per request type, and professional provider category (e.g., OT, PT, SLP, and Educator).

On Going Support refers to services requested/provided to support a student past the initial evaluation, trial, and implementation stages and is typically tied to IEP service minutes. AT Assessment refers to a formal student evaluation related to AT, including opening student domain paperwork, gaining parent permission, and formalizing results in an IEP document. AT Consultation refers to a request for an AT staff member to consult with a teacher or team around problem-solving general student support related to technology. AT Trials refer to service that begins after an evaluation has been completed and technology support needs have been identified. The team and AT staff engage in trials to identify specific tools to meet the student support needs. AT Training refers to requests for AT staff to provide specific professional development sessions within member districts. AAC Problem Solving refers to requests for AT staff to help district teams problem-solve specific situations related to augmentative and alternative communication (AAC) devices. Table 1 depicts service hours per professional service provider and service category provided to ESA member districts.

***Table 1: Service History Hours by Provider Profession and Service Category***

| | | 2010-2011 | 2011-2012 | 2012-2013 | 2013-2014 | 2014-2015 | Total |
|---|---|---|---|---|---|---|---|
| OT | On Going Support | 197.7 | 192.1 | 363.7 | 319.6 | 110.5 | 1183.6 |
| | AT Assessment | 103.4 | 147.4 | 397.4 | 218.8 | 110.5 | 977.5 |
| | AT Consultation | 38 | 67.3 | 45.5 | 48.6 | 55.1 | 254.5 |
| | AT Trials | 84.8 | 27.4 | 0 | 0 | 0 | 112.2 |
| | TOTAL SERVICE | **423.9** | **434.2** | **806.6** | **587** | **276.1** | |
| Educator | On Going Support | 0.2 | 46.6 | 52.8 | 19 | 0 | 118.6 |
| | AT Assessment | 188.2 | 288.4 | 494.2 | 306.5 | 9.8 | 1287.1 |
| | AT Consultation | 14.8 | 120.6 | 88.8 | 100.9 | 13.6 | 338.7 |
| | AT Trials | 67.3 | 232.5 | 0 | 0 | 21.8 | 321.6 |
| | AT Training | 122.1 | 13.7 | 0 | 0 | 0 | 135.8 |
| | TOTAL SERVICE | **392.6** | **701.8** | **635.8** | **426.4** | **45.2** | |
| PT | On Going Support | 260.5 | 88.7 | 106.1 | 157.8 | 118 | 731.1 |
| | AT Assessment | 27.3 | 91 | 52.1 | 0 | 0 | 170.4 |
| | AT Consultation | 37.2 | 3.3 | 1.2 | 0 | 0 | 41.7 |
| | AT Trials | 0 | 0 | 0 | 0 | 0 | 0 |
| | AT Training | 0 | 0 | 0 | 0 | 0 | 0 |
| | TOTAL SERVICE | **325** | **183** | **159.4** | **157.8** | **118** | |
| SLP | On Going Support | 327.5 | 127 | 195.8 | 236.2 | 50.5 | 937 |
| | AT Assessment | 135.3 | 368.3 | 281.6 | 470.1 | 38.2 | 1293.5 |
| | AT Consultation | 64.8 | 7.9 | 59 | 59.3 | 0 | 191 |
| | AT Trials AAC/Problem | 18.8 | 0 | 0 | 0 | 3.3 | 22.1 |
| | Solve | 390.4 | 122.3 | 0 | 0 | 0 | 512.7 |
| | TOTAL SERVICE | **936.8** | **625.5** | **536.4** | **765.6** | **92** | |

Historical service data show that while almost all AT service categories trend downward, AT Consultation and AT Assessment show slight upward trending for the OT profession, and AT Consultation trends neutral for the Educator profession. In addition, AT Assessment and AT Consultation show only slight downward trending for the SLP profession. This trend may indicate that member districts still value AT Consultation and AT Assessment services, although they may be meeting some of these high-incidence needs in-house and using the ESA AT department for the more involved student cases (low incidence). This pattern has implications for future AT roles in increasing support to the high incidence population.

Given general trends toward increasing use of instructional technology, it is interesting that the AT Educator professional category has a sharp decline in service provision. This may be because the trend toward instructional technology coaching is still developing and not yet reflected in the data. It may also be because educators are ubiquitous in school districts and thus more used for in-house capacity around instructional technology needs versus out-sourcing these needs to the ESA AT department.

## Survey Data

The author sent surveys to stakeholder groups to explore the perceived benefits of current ESA AT department services. Qualitative follow-up questions sought information regarding the perceived role of the ESA AT department and the perceived areas of need or challenge for the ESA AT department. External stakeholders included the special education directors (SPED) in member districts, member district non-SPED administrators, and member district end users of ESA AT services. Internal stakeholders included ESA AT department members.

Member district SPED administrators are ultimately the ESA's identified customers because they are responsible for district budget categories that include related services. They have the decision-making power on a large scale for ESA services. Their view is typically broader in scope and focuses on the overall philosophy of service, including decisions to build staff capacity, to move from an expert to a coaching service model, and/or to hire in-house AT service providers versus hiring services from the ESA. While their view is broader, their experience is often somewhat removed from the actual service provided and the student-AT service interaction. Eighteen surveys were sent to this group (one to the SPED in each member district) and 11 surveys were returned (61%).

The member district non-SPED administrator category captures several district-specific titles. These are the special education administrators who typically have direct oversight of related service providers and manage individual student IEP processes. They bridge the gap between the administrative big picture view and direct involvement in daily student programming and district staff support. These are typically the administrators with whom AT team members have the most direct contact. Twenty surveys were sent to this group and five were returned (25%).

ESA member district end users surveyed consisted of teachers, school psychologists and technology specialists who had worked with the ESA AT department concerning students and referrals. These are district staff with the most direct experience with the ESA AT department members and the most experience with the available service provision offered by the ESA. Their involvement is closely linked with actual service provision and less linked to budgetary aspects. Fifty-four surveys were sent to this group and 13 were returned (24%).

The internal stakeholder group, the ESA AT department, was also surveyed. This group has significant insight into the needs of the various member districts at each stakeholder level. Seven surveys were sent to this group (one to each AT staff member) and five were returned (71%).

## Quantitative Survey Data: Comparisons Across Stakeholder Groups

In general, all stakeholder groups perceive the majority of services offered by the ESA AT department to be very or somewhat beneficial (over 50%). If the two categories (very and somewhat beneficial) are separated, the results change. District SPED administrators perceive only wheelchair/mobility evaluations (87.5%) and equipment loans/training (76.9%) very beneficial at over 50%. Over 50% of district non-SPED administrators perceived all AT services as very beneficial except consultation to staff around technology in general (20%) and technology networking groups (20%). Over 50% of district end users perceived all AT services as very beneficial except technology networking groups (23.1%). The perception of benefit of services lowers the further it moves away from the end users. District SPED administrators have a lower perceived benefit of AT department services than do other district groups.

Important contrasting data exist among stakeholder groups. District SPED administrators perceive limited benefits to consultation to staff around technology in general, but non-SPED administrators and district end users perceive this service as very beneficial (66.7%).

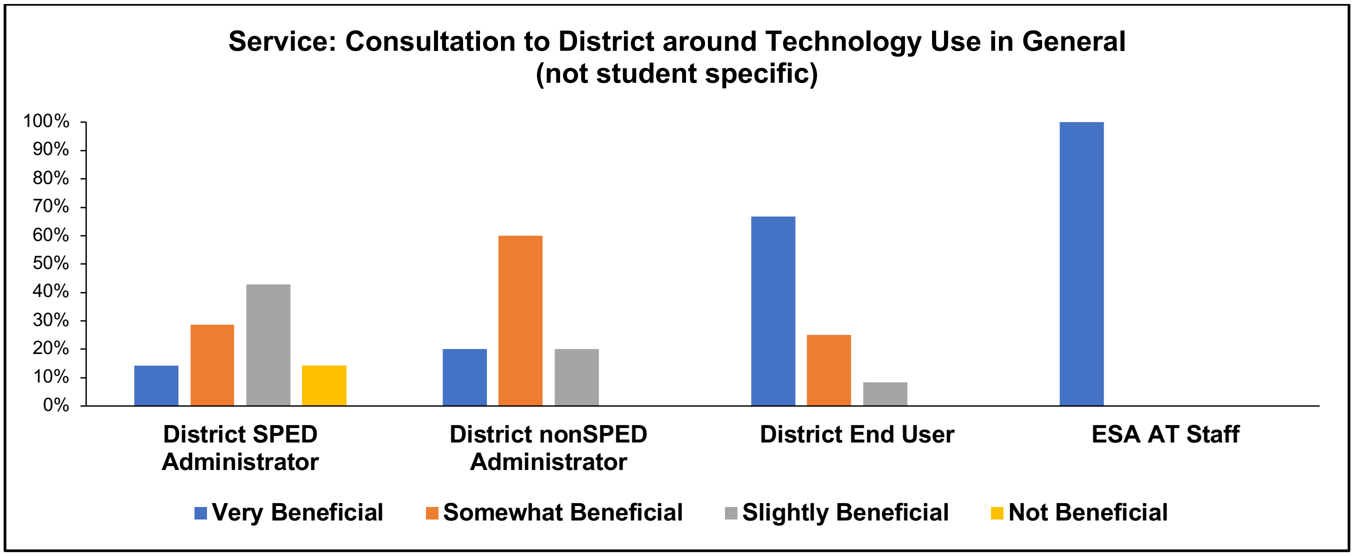


***Figure 1: Consultation to District Around Technology Use in General***

District SPED administrators place less benefit around on-going student support while non-SPED administrators and district end users rank this as one of highest perceived benefits (100% non-SPED administrators; 92.3% district staff).

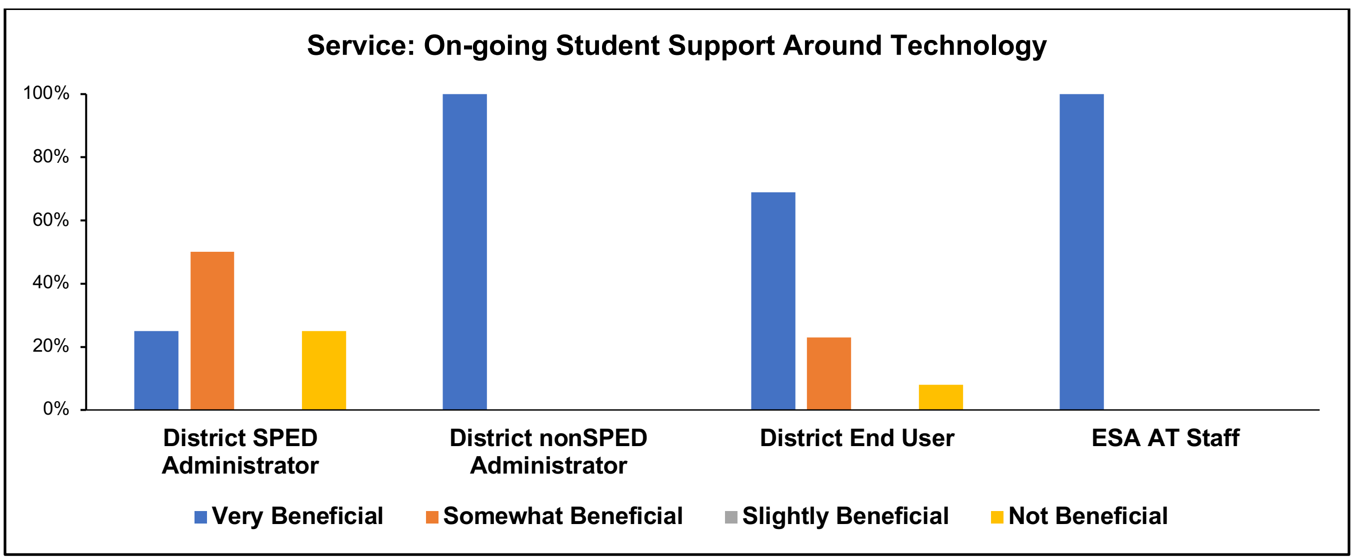


***Figure 2: On-going Student Support Around Technology***

Another contrasting category consists of coaching staff around student-related technology. District end users perceive this to be very/somewhat beneficial at 100% (84.6% very beneficial; 15.4% somewhat beneficial) and 71.2% SPED administrators find this service to be very/somewhat beneficial (35.7% very beneficial; 35.7% somewhat beneficial).

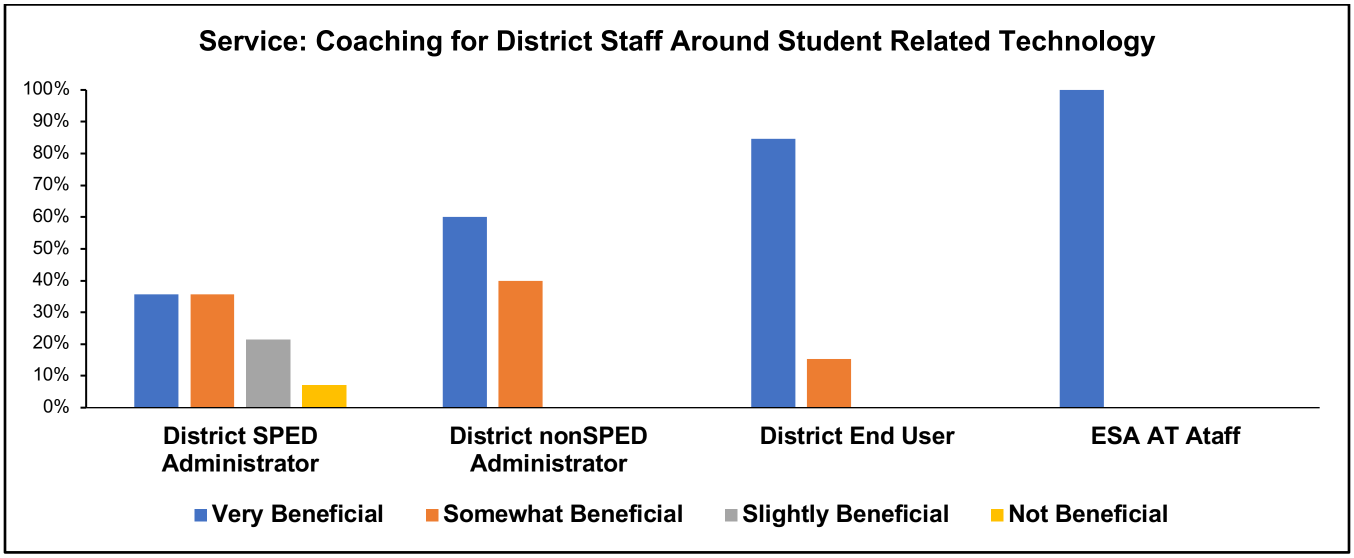


***Figure 3: Coaching for District Staff Around Student Technology***

There are also general contrasts in perceived benefits of AT department services between upper district administration and next level administration and end users. In general, district SPED administrators perceive services around professional development (PD) and low incidence services (i.e., wheelchair/mobility evaluations and equipment loans/training) as most beneficial services while non-SPED administrators find on-going student support most beneficial, and district end users find coaching around student-related technology most beneficial. These conflicting perceptions of benefit make it difficult to develop services that meet all stakeholder needs.

## Qualitative Survey Data Results

The author coded qualitative survey responses by stakeholder group and across stakeholder groups to determine data patterns and similarities and contrasts among groups. A "Miscellaneous Responses" category was used for responses not common among stakeholder groups.

Table 2 depicts coded data responses from the question around perceived role of the ESA AT team in supporting individual districts. Stakeholder groups agree the ESA AT department should be experts in technology. This included responses around the AT team being able to provide highly customized strategies and supports for individual students, being experts about highly specialized technology, being updated in all and changing technology, and understanding the link between technology and education.

***Table 2: What is Role of AT Department in Supporting Districts?***

| SPED Admin | Non-SPED Admin | District End Users | NSSED AT Team |
|---|---|---|---|
| Experts in AT | Experts in AT | Experts in AT | Experts in AT |
| Build Capacity | Build Capacity | | |
| Low Incidence Support | Low Incidence Support | | |
| On-going coach/consult | | Coaching | Coaching |
| Wheelchair Mobility | | Mobility | |
| PD/Networking | Train/Support Teachers | Train Students/Adults | PD |
| | AT Evaluations | AT Evaluations | AT Evaluations |
| **Miscellaneous Responses** | | | |
| Team Problem Solving | | Loaning Equipment | Provide Range of Services |
| | | Technology Assistance | Technology Implementation |
| | | AT Written Language | |

Table 3 depicts coded data for responses to the question around the ESA's role in supporting technology in general in member districts. Data showed agreement around providing PD/training around technology and some agreement that the ESA did not have a role in this area. Miscellaneous areas included ESA AT team responses.

***Table 3: What is ESA's Role Around Technology in General in Supporting District?***

| SPED Admin | Non-SPED Admin | District End Users | NSSED AT Team |
|---|---|---|---|
| PD-Cutting Edge | PD | PD | PD/Training |
| None | | None | |
| **Miscellaneous Responses** | | | |
| Group Purchases | Build In-house capacity | Expert in AT | Networks |
| Creative Problem Solving | Be Experts; Keep Current | Support Student Tech | Coach |
| | | | Coordinate |
| | | | Support Tech Coaches |
| | | | Support 1:1 Initiatives |

Table 4 contains coded data responses for the question around other services ESA member districts thought might be beneficial (program expansion). The responses highlighted PD/training as an on-going need identified by all stakeholder groups and included PD for specific groups (e.g., administrators, specific teachers/districts) and PD tailored to specific technology (e.g., training around apps, training around technology on a global level, etc.) or PD in specific formats (e.g., on-line or on-demand learning).

Table 5 depicts coded responses to the question soliciting information as to where the ESA has failed to meet district needs and/or expectations around technology. The category of training was raised as a growth area. District non-SPED administrators proposed adapting PD offerings to better meet needs and ESA AT team members indicated a need to change and expand trainings/PD format and access. The ESA AT team responses identified service mistakes including the belief that the ESA was late in identifying the impact iPads would have in educational environments, missing the importance of coaching in technology, and marketing coaching as a service option instead of the expert model. The ESA AT team also recognized limited follow up beyond AT evaluation and lack of on-going support to teams.

***Table 4: What Other Technology-Related Services Should the AT Department Provide?***

| SPED Admin | Non-SPED Admin | District End Users | NSSED AT Team |
|---|---|---|---|
| PD | PD | PD | PD/Training |
| Nothing | | None | |
| Hub: Link District Initiatives | Networking Groups | | Coordinate/Network |
| **Miscellaneous Responses** | | | |
| Increased Collaboration Times | Follow-up: On-going support | Updated info/Apps | Marketing |
| Group Purchases | Build Capacity | Lending Library | Coaching |
| Parent Education | | | |
| Cloud-based Support | | | |
| Link NNSED and District Tech | | | |

***Table 5: Where Has the AT Department Missed the Mark in Meeting Districts' Needs?***

| SPED Admin | Non-SPED Admin | District End Users | NSSED AT Team |
|---|---|---|---|
| | No Concern | No Concern | |
| | Trainings | | On Demand Training |
| | | | Administrator Training |
| | | Coaching | Marketing Coaching |
| **Miscellaneous Responses** | | | |
| Evaluation Format | | High Incidence Students | Experts in Tech (iPads) |
| Parent Involvement | | Access to Professionals | On-going Student Support |
| Coach On-call vs. Fee-for -Service | | Mapping Multiple Services | |
| Tiered Approach | | | |

# Discussion

## A New Stage of Development for ESAs

Information was gathered and interpreted regarding the changing nature of ESAs as a specific aspect of public education environments. If ESAs are in a fifth and potential end stage of Evolution or Dissolution, the connection can be drawn that service departments within ESAs are also facing some aspect of this developmental stage, hinting at a potential for dissolution if structural service changes toward evolution are not made. If ESAs undergo a process of evolution, the role of AT departments within them will be impacted. The discussion of evolving states of ESAs and their service departments (AT) cannot be held in isolation. The factors impacting ESAs arise from and in turn impact the larger public education arena. Therefore, these research results are also applicable to AT departments outside ESA structures in public education. The unique position of AT departments within ESAs means that they exist in the middle of changing internal and external environments.

### The Role of Assistive Technology Departments in Public Education Structures

Literature review and research data indicate that the role of AT departments in public education structures such as ESAs is to support districts and end users through changing environmental and educational contexts by becoming thought leaders around all aspects of technology, being experts in technology from assessment to implementation to future trends, and by becoming partners with districts in programming and support related to technology.

*Technology thought leaders.* Assistive technology departments and staff must be leaders in identifying the impact to educational curriculum and planning that advances in technology pose. This thought leadership should go beyond simply identifying new trends and new technologies into the diagnostic aspect of understanding how the technology will impact all levels of educational programming. The nature of ESAs means that AT team members have daily exposure to and access to professionals in many districts and across numerous educational programs from self-contained classrooms to general education classrooms. They can synthesize experiences and education from multiple sources and bring this wealth of knowledge to the larger field of educational technology. This wide and constant exposure makes them well-placed to lead thought around the intersection and merging of education and technology across a broad range of educational environments.

*Experts in technology.* The role of experts in technology is similar to thought leadership in some ways, but diverges in depth and breadth of knowledge. The technology expert role is not the same as the expert model of service delivery. The technology expert role means that the members of AT departments are tasked with and uniquely suited to having a depth and breadth of knowledge around low-incidence technology (e.g., eye-gaze systems) and how to feature match the innumerable technology apps available in the marketplace to high incidence classroom support. Further, this technology expertise must be matched with extensive developmental and medical knowledge for the low-incidence student population and extensive educational programming knowledge to match technology to educational tasks. Skilled assessment, diagnostics, and technology support for high-incidence and low-incidence student populations is a necessity.

*District partners in programming.* AT departments and staff must broaden their role to inclusive partnering with districts, beyond services to specifically-identified students. Providing services on a student-by-student basis is not an efficient use of AT expertise and is not a feasible method of addressing the burgeoning high-incidence student population. As technology becomes more prevalent in districts, the support to students around technology is also expected to become more pervasive, requiring AT professionals to be accessible and to broaden their role to include instructional universal curricular design and technology support. This more accessible AT department role in supporting districts was seen in survey language including "Coach on-call," "team support," "build capacity," "on-going coaching," "consulting," "training teachers/staff," "curriculum specific support," "parent involvement," "high incidence," "access to AT professionals." Survey data indicates traditional services such as student-based services including AT assessments and on-going student support are no longer seen as the most beneficial services. However, newer service models such as coaching and consultation are not fully yet accepted as alternative service models. This implies that AT departments and programs are on the cusp of a real and needed adaptation if not evolution.

By the layered nature of the organization, the roles identified for AT departments in ESAs are more complex than those within a single district. Meeting the needs of member districts of varying sizes, philosophies, and cultures while meeting the internal expectations of an evolving ESA can be challenging. It requires having a strong understanding of all change forces applied to all public education in general and being able to apply that knowledge in a forward-thinking manner to assistive technology services.

## Future Programming

Given that the change forces impacting ESAs are in alignment with the change forces impacting public education in general, the programming implications resulting from this investigation are applicable to AT departments in all public education settings. Research and literature review results permit a programmatic design framework calling for planning implications in departmental structure and departmental services.

### Departmental Structure

Flexible scheduling options that allow AT staff to expand their role of operation are needed. Engaging in proactive curricular design and expanded models of PD require staff time beyond student-by-student remediation. Budgetary constraints are often listed as main reasons for this structural restriction. However, this investigation indicates that providing this proactive support to staff and students is a more efficient structural model and is more aligned with current educational initiatives. Clarified roles and service definitions allow AT personnel to market and document their services and the increased impact of new service structures. Service marketing must be designed to increase administrator awareness of the full range of services offered. This marketing must include the value-added aspect of the AT departments inherent in district and/or ESA structures. Finally, it is necessary to hire and train personnel who are comfortable with a broad array of service provision models and are willing to move beyond the expert model of service provision.

### Service Provision

Alternative service models that match district needs and that align with cutting edge best practices and new technology must be put in place. Assistive Technology departments must recognize the broader range of services now being considered under the AT umbrella (instructional support, technology coaching, etc.). Increased focus on types and formats of professional development and professional development offerings tailored to various and specific stakeholder groups must be provided. Assistive technology staff need to be versed in the subtle language that distinguishes service formats such as instructional versus assistive technology, and the scope of service must be broadened.

Once this broader service provision scope is provided, utilizing strong business and marketing principles will allow AT departments to disseminate knowledge and spur interest in the new face of technology that is developed. Competing with new initiatives in districts can be difficult, and specific and tailored marketing efforts can capitalize on individualized district needs as well as individualized strategies developed to support these needs. Ultimately it is important to note that within ESAs as well as within other public education structures, those who have the authority to approve utilization of AT services are often the furthest removed from direct student services, and the data indicate that this removal from student service provision is linked with less satisfaction around offered services. Linking service provision to this level of administration will increase satisfaction and service usage.

## Study Limitations

Several limitations are inherent in this investigation that can impact data interpretation. Due to the historical nature of service records, service categories were not well defined or documented, leading to a need to carefully interpret potential service trends by professional category. Survey data participation was limited in some stakeholder groups.

Member district non-SPED administrators and the member district end users had limited survey responses (25% non-SPED administrators; 24% end users). This may have been due to the fact that it was gathered in April, which tends to be a busy time in public schools. In addition, the high turnover rate at the non-SPED administrative level is a limitation as programming based upon responses garnered from these administrators may not have a service impact with new district administrators. Also, member district end users were not asked about coaching services to district technology leaders as they are not in a position to employ district leaders in coaching positions. In retrospect, it would have been appropriate to keep the survey consistent for all stakeholder groups as district staff may have valuable insight into this area.

## 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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# Accessibility User Research Collective: Engaging Consumers in Ongoing Technology Evaluation

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## Abstract

The rapid pace of change in consumer technology requires structures and mechanisms to ensure ongoing engagement of consumers with disabilities so that new and updated products and services are accessible and useful. This article reviews the rationale, creation, operation, and impact of the Accessibility User Research Collective (AURC), a partnership between Microsoft and Shepherd Center, a rehabilitation hospital for traumatic injury and neurodegenerative diseases, to create and maintain a national network of people with all types of disabilities to provide ongoing customer input and testing of Microsoft products and services. The AURC is modeled after the Consumer Advisory Network (CAN) concept developed by Shepherd Center staff under the Rehabilitation Engineering Research Center for Wireless Technologies (Wireless RERC) and continued in recent years by the LiveWell RERC. The concept is to build a national network of consumers with disabilities who can be recruited to participate in targeted usability and needs-discovery studies.

***Keywords:*** information and communication technology, accessibility, usability, user-testing

## Introduction

Equitable access to information and communication technology (ICT) goes beyond concern with technological fairness. In the current era and beyond, access to ICT is essential for community and economic participation (job, career, and professional opportunity) and independent living. These days, not having access to ICT severely limits access to work and community. It literally means not being part of the conversation. This is why the United Nations Convention on Rights of Persons with Disabilities (UNCRPD) requires signatory states to: “promote access for persons with disabilities to new information and communications technologies and systems, including the Internet” and “promote the design, development, production and distribution of accessible information and communications technologies and systems at an early stage, so that these technologies and systems become accessible at minimum cost” (United Nations, 2006, p. 10).

The rapid and accelerating pace of innovation in consumer technology poses ever greater challenges to accessibility and usability by people with disabilities. Historically, new consumer technology products usually were aimed first at the general market and later addressed access needs of other consumers. Meanwhile, established mass consumer ICT products are in an almost constant state of updating and revision, which can often undo hard-won accessibility solutions (Wentz & Lazar, 2017; Schroeder & Burton, 2010). This environment of nearly constant technological change and increasing commitment of industry to provide accessible technology requires equally constant engagement with users with disabilities to ensure equitable access.

For ICT vendors, the dual challenge is to include accessibility considerations in the design and development work of new products while making sure that there is no regression – that the accessibility gains in existing products are not broken or undone. Additionally, research focusing on discovery of needs for usefulness is essential. Ideally, efforts to discover needs of users with disabilities and to ensure accessibility should be continuous and programmatic given the rapid pace of technology innovation and constant updating of ICT products.

This article reviews the rationale, creation, operation, and impact of the Accessibility User Research Collective (AURC), a partnership between Microsoft and Shepherd Center, a rehabilitation hospital for traumatic injury and neurodegenerative diseases, to create and maintain a national network of people with a variety of disabilities to provide ongoing customer input and testing of Microsoft products and services. The AURC launched in August 2017 after several months of planning and has been refined in its first year of operation. It was created to establish a channel for direct interaction with consumers with disabilities on an ongoing basis. The foundation of the AURC is a national network (collective) of people with disabilities from which AURC staff at Shepherd Center recruit for specific accessibility, usability, and user needs studies requested by Microsoft product and research teams. To date, the AURC counts over 750 members across multiple disabilities and diverse demographic backgrounds. During its first year the AURC launched 17 studies (completing 14) of various types for Microsoft product and business groups—usability, needs-discovery, and general ideation sessions.

Vendors in the consumer technology space and other industries have multiple options for engaging users, including those with disabilities, in product design. These options include operating onsite testing centers (organized either by major product line or as a company-wide effort) and hiring external market research companies to conduct product testing and user-needs discovery research. Research staff at Shepherd Center has worked with two large ICT vendors who noted that their facilities pose access challenges by people with disabilities because they usually are highly secure environments in large office parks that are not on public transportation lines. Private market research agencies usually do not have the required expertise in disability and accessible/assistive technology. For both, the known available population of people with disabilities in the local area in which they operate can be quickly exhausted, leading to over-engagement of the same finite set of individuals with a specific disability and other inclusion criteria (e.g., demographic and technology profiles). This raises the risk of testing with participants who have developed too much expertise either in the specific product type or in general product testing (i.e., participants become unrepresentative of typical users).

Another option is to engage a company's disability resource group (DRG), one of several types of employee resource groups (ERGs) that a company (especially large companies) may support. Employee resource groups are identity-based groups staffed by employee volunteers. Originally called "affinity groups," ERGs first appeared in the 1960s when racial tensions were rising in the United States to help businesses promote diversity and inclusion goals (Welbourne, Rolf, & Schlachter, 2017). Since then, companies have expanded their support of ERGs pursuing a broad range of diversity and inclusion goals, including: gender, race, and ethnicity, generational, sexual identity, veterans, faith-based, disability, and more (Mercer, 2011). In recent years, the goals of ERGs have evolved "to include organizational challenges such as leadership development, innovation, and change management, which should translate to significant research from the academic community" (Welbourne, Rolf, & Schlachter, 2015).

Microsoft has a DRG (called disAbility), as do other ICT vendors such as Dell (True Ability), HP (DisAbility), AT&T (Individuals with Disabilities Enabling Advocacy Link, or IDEAL) and Verizon (Disabilities Issues Awareness Leadership, or DIAL). ICT vendors with which research staff at Shepherd Center has worked occasionally engage the membership of their DRGs for input into product development and other initiatives focused on disability and accessibility. Such groups are an important resource for product development, but they represent only one of a set of resources utilized for product testing and user input. ERGs are generally volunteer organizations (Kaplan, Sabin & Smaller-Swift, 2009), despite sometimes receiving corporate financial and other material support. Consequently, participation in group activities is voluntary. The AURC has sent recruiting communications to the membership of Microsoft's disAbility group, but their participation in AURC studies is treated as voluntary, just as with any other private individual not on Microsoft's payroll. Many of these employees have full-time jobs that generally do not involve market research, product testing or development from a disability perspective. Furthermore, companies like Microsoft have large product portfolios which undergo continuous development, making the need for gathering systematic user input much bigger than the ability of DRGs generally to fulfill.

The AURC serves as an additional resource—along with internal product testing operations, external market research vendors, disability resource groups, and other mechanisms for engaging people with disabilities—to assist with the ongoing and expansive need to engage people with disabilities in product development and evaluation at Microsoft.

## Outcomes and Benefits

The AURC partnership between Microsoft and Shepherd Center offers insights into a model for ongoing consumer engagement in product design and development specifically focusing on the accessibility and usability needs of people with disabilities. By providing accessible products and services, Microsoft can help people with disabilities gain access to education, employment and connection with governments, friends, and family. The AURC database and engagement design is based on the Consumer Advisory Network (CAN) network of consumers and Survey of User Needs intake questionnaire that Shepherd Center researchers developed, in order to respond to the fast paced and continuously evolving technology industry (Mueller, et al., 2005). Like the CAN, researchers from the Shepherd Center created and maintain the AURC, but in collaboration with Microsoft. For almost two decades, Shepherd Center researchers have been building and maintaining the CAN for the Rehabilitation Engineering Research Center for Wireless Technologies (Wireless RERC) and currently for the Rehabilitation Engineering Research Center for Community Living, Health and Function (LiveWell RERC). The description of how this model was adapted to support the product accessibility design needs of a single large ICT vendor with its own processes and often urgent timelines should help inform other rehabilitation researchers and ICT vendors interested in launching similar programs.

## Target Audience and Relevance

This work is relevant to rehabilitation researchers and engineers in academic or other non-profit organizations and for-profit organizations interested in connecting consumers with disabilities and technology developers, particularly in the private sector. It is also relevant to the assistive technology industry and to consumer-oriented ICT vendors. This article provides insights and a model for how researchers in non-profit organizations and industry can partner to promote accessibility and usefulness of commercial ICT products and services for people of all abilities.

## Background

The rapid pace of change and variability of devices with which consumers interact over the course of their day poses substantial challenges to usability, interoperability, and accessibility. Over the last four decades, consumers have experienced the benefits—and challenges—of successive technology innovations, each one appearing more quickly than the previous one and collectively forming complex technology ecosystems. Major technology milestones in this period include the commercialization of personal computers, the internet, laptops, cellphones, smartphones, app stores for mobile apps, personal digital assistants, wearable smart devices and sensors, cloud computing, the Internet of Things (IoT), smart speakers, smart home devices for control and automation, artificial intelligence, and virtual and augmented reality.

These innovations are sometimes referred to as revolutions (Internet revolution, smartphone revolution, etc.). It might be more appropriate to view these major innovations as having a cumulative effect, adding to consumers' personal technology ecosystem, rather than completely overthrowing the previous order. This means that challenges of interoperability, reliability, and usability are multiplied as mature technologies continue to undergo refinement and new technologies are added to the mix. While desktop computers have experienced declining sales for over a decade, and laptops follow a similar pattern, they still sold at a combined rate of 399.7 million units in 2017 (Statista, 2018).

Personal computers became established as a staple of professional and personal life in the 1980s, followed by the advent and maturation of internet as an essential medium for information and communication—and later commerce—in the mid-late 1990s. The rapid evolution and diffusion of mobile phones and supporting infrastructure in the 2000s laid the foundation for a transformation in the way we work, play, socialize, and access information. Mobile voice-calling, video chat services, and two-way text messaging also provided an unprecedented boost to the independence of people with disabilities, particularly people with vision and mobility limitations and, in the case of text messaging, people who are deaf.

The era of smart devices could be said to have begun in the early 2000s, led by Research in Motion with its Blackberry devices. But, it was the launch of Apple's iPhone in June 2007 and the first Android smartphone (the HTC Dream/T-Mobile G-1) in September 2008 that dramatically and thoroughly overthrew the established technology order. Within a few years, the two top cellphone handset makers Research in Motion (RIM, maker of the BlackBerry) and Finland-based Nokia became minor players, and eventually became either niche manufacturers of devices running the Android operating system. The new generation of touchscreen smartphones come loaded with global positioning systems (GPS), 3G (then 4G, and soon 5G) telephony, Wi-Fi, Bluetooth, accelerometers, digital personal assistants, and more recently fingerprint recognition, facial recognition, iris-scanning, and more.

Smartphones and their near-cousins, tablets (iPad, Samsung Galaxy Tab, etc.), created the opportunity and need for mobile applications (news, weather, games, email, maps, etc.). Apple established the model for how these apps would be developed and brought to market by launching the AppStore for its iPhone with 552 apps on July 11, 2008. Ten years later, the AppStore boasts over 2 million apps, and has generated $130 billion in revenues for over 170 billion app downloads (Cheney, 2018). The Android Market launched in 2008 and was rebranded as Google Play in 2012 as a way to consolidate Google's online marketplace for apps, movies, music, books, and other digital content. It boasts over 2.7 million apps and games (Callaham, 2017).

In recent years wearable devices and smart speakers have been gaining traction in the marketplace. Smart watches and fitness trackers have been widely available for a number of years and have experienced relatively slow adoption and high rates of abandonment (Gartner, 2016). Smart speakers—relying primarily on a voice/auditory interface driven by a personal digital assistant—were essentially created as a category of consumer electronics by Amazon in 2015 with its Echo device. Others followed, including Google with its Home device and OK Google digital assistant, and the Cortana-powered

Harman-Kardon Invoke. These devices have now formed the hub (along with smartphones) for home automation and control for things like lights, thermostats, doorbells, security cameras, TVs, and more.

Usability challenges remain for the smart home/smart assistant. Controlling multiple smart home hubs (e.g., Echo, Echo Dots, Echo Show) can be confusing on a single mobile app. Having multiple connected devices in your smart home can make learning their dialogue path (e.g., “Alexa, …”) and names complicated and confusing for users, family members, and guests (Stinson, 2017). Early versions of Google Home could not set reminders (Murnane, 2017)—a key assistive function for people with difficulty remembering. One reviewer noted that a requested list of ingredients for a recipe was spoken too fast (even at the optional slower rate) to be useful (McGregor, 2017). The Echo Dot and later versions of the regular Echo do not offer the manual volume control that allows the user to turn the entire top of the cylindrical device found on the original Echo. So, changing the volume must be made vocally or by pressing unlighted buttons on the top of the device.

Wearable technology, which is expected to grow from $1.5 billion in 2014 to $34 billion by 2020 (Lamkin 2016) and $51.6 billion by 2022 (Markets and Markets, 2017), also offers great promise and challenges for people with disabilities. However, the technology remains immature. A 2016 Gartner survey of the U.S., U.K., and Australia found that adoption rates remained low for smartwatches (12% or less) and fitness trackers (23% or less) (Gartner, 2016). Meanwhile abandonment rates for smartwatches and fitness trackers remain high (29% and 30%, respectively, across the 3 countries), which, according to Gartner, is the result of the need for wearables to be more useful (Gartner, 2016). Preliminary results of a survey of people with disabilities conducted by the LiveWell RERC found that usability and accessibility concerns of health and fitness tracking apps and devices were common (Jones, Morris & DeRuyter, 2018). Many respondents requested compatibility with existing AT or alternatives to manual keypad entry. Respondents with activity limitations requested diet and exercise apps that could more accurately measure activity levels (e.g., when using a wheelchair or other mobility aid) or allow for adjustments to diet/nutrition goals to suit their more limited caloric intake needs.

These trends and examples of persistent usability barriers point to the pressing need for ongoing usability research and engagement with consumers with disabilities.

## Microsoft in the Current Technology Environment

Microsoft’s large and diverse portfolio includes products that are central to consumers’ personal and professional lives, including the Windows operating system, the Office suite of productivity applications (Word, Excel, PowerPoint, as well as Access database and Publisher applications), Outlook for email, Skype for voice and video communications, Xbox gaming platform, and more. This broad portfolio of widely used and complex applications requires constant maintenance, updating, and patching for security, functionality, and accessibility.

These products must continue to operate smoothly and reliably within complex and rapidly evolving ecosystems of hardware and software produced by many different vendors. Additionally, they must comply with requirements for data security and privacy, as well as with national and international requirements for accessibility by people with a range of physical, sensory, and cognitive limitations.

Microsoft's rollout of Office 365, beginning in 2011 for business customers and 2013 for consumers, represents a key response to these imperatives. Office 365 is a subscription-based license (so-called "shrink-wrap" licenses with perpetual ownership by the customer has historically characterized much of consumer software licensing) that also offers cloud computing, cloud data storage (OneDrive), and automatic, no-cost updates for the life of the subscription. From the launch of Office 1.0 in 1990 through Office 2016 this comprehensive suite of productivity tools underwent major version upgrades approximately every 2 years with numerous updates in between (Newegg Business, 2015). The pace of product development for Office 365 is much faster. Microsoft has produced and released 19 builds of Office 365 Pro Plus through its monthly update channel through June 2018. It released 37 builds for the full year in 2017, and 35 builds in 2016 (Microsoft, 2018).

Office 365 is a leading example in the growing industry trend of offering what is known as "software as a service" or SaaS (Vladimirskiy, 2016). Other offerings in Microsoft's broad portfolio of products are under similar demands for constant updating. Managers of various Microsoft products have indicated their urgency for consumer input because of this accelerated tempo of product development. Reasons for such a rapid tempo of product development include: 1) compatibility – ongoing demand for stable functionality and interaction with other technologies; 2) reliability; 3) compliance with standards bodies (e.g., International Organization for Standardization, or ISO) and statutory/regulatory requirements; 4) security and privacy (e.g., new European Union data privacy requirements); and 5) accessibility.

## Accessibility User Research Collective

The idea of creating the AURC came from Microsoft's Corporate and External Legal Affairs (CELA) group, which was looking to provide company-wide resources to the individual product teams to increase the quantity and quality of feedback from the disability user community and support inclusive design principles and the accessibility and usability of products and services. Product teams were often responsible for engaging users with disabilities but were faced with some challenges. The central challenge was identifying and recruiting a large, diverse sample of people with disabilities to participate in user research.

One way to accomplish this is to engage national or local disability advocacy organizations (Hearing Loss Association of America, National Foundation of the Blind, etc.). Alternatively, product teams could engage external market research companies to recruit and screen participants to match specific inclusion criteria. These approaches were, and still are, used. But it can be inefficient and redundant to have multiple product teams building and maintaining their own set of relationships with multiple disability organizations and third-party market research firms. Furthermore, some teams found that they had exhausted the available pool of participants and were including many of the same participants in successive studies. As participants became familiar with using Microsoft products and conducting studies with the same teams, they gradually became less representative of the typical user with their same disability.

Accessibility professionals at Microsoft already knew of Shepherd Center due to their long history of serving in an advisory capacity for the Wireless RERC, which created the consumer network model of user-centered research. In 2001, the Wireless RERC launched its Consumer Advisory Network (CAN) of people with disabilities and made it the cornerstone of consumer engagement over the succeeding years (Mueller, Jones, Broderick, and Haberman, 2005). Responding to the needs and challenges that Microsoft product teams faced in engaging users with disabilities, Microsoft's CELA group partnered with Shepherd Center's assistive technology/accessibility researchers to design and launch a national, dynamic, and enduring networking of people with disabilities who are interested in testing and providing feedback on technology products.

## Structure

The foundation of the AURC's consumer network model for testing and needs discovery is a large national network whose members complete an intake form, a detailed questionnaire with demographics (age, gender, etc.), disability profile, technology profile, and contact information. The database of information serves as a resource for understanding technology use patterns for a specific consumer profile (e.g., deaf videogame console users, age 18-35). Shepherd Center researchers working on the Wireless and LiveWell grants have produced a number of publications and conference papers on analysis of their Survey of User Needs—the intake questionnaire for their Consumer Advisory Network—to answer specific questions on technology usage by consumers with disabilities (Jones, et al., 2018; Morris, Jones & Sweatman, 2016; Morris & Mueller, 2016; Morris, Mueller, & Jones, 2010).

The database questionnaire can be completed either online, by phone, or on paper. The overwhelming majority of members complete the questionnaire online. The questionnaire and database were built in REDCap (Research Electronic Data Capture), a secure web application for building and managing online surveys and databases originally created by Vanderbilt University for clinical research, and now available to other institutions via the REDCap Consortium. Shepherd Center is a member of the consortium, and its clinical research department uses REDCap to track research projects, research participants, and stipend payments. A key part of the service that the AURC provides to Microsoft is payment of participant stipends, which a smaller organization like Shepherd Center (with approximately 1500 employees) can undertake more efficiently than a large multinational technology vendor.

The main intended use of the AURC database, however, is as a resource to recruit individuals with specific demographic, disability, and technology profiles to participate in small individual usability and needs discovery studies. These studies usually include between 10 and 20 participants. Most studies are conducted remotely; data are usually collected via an online survey service like Survey Monkey. Some projects are conducted in person. To date, these have taken place in Atlanta, where Shepherd Center is located. Other locations may be used going forward.

Because the AURC is staffed exclusively by Shepherd Center personnel and stipend payments are made directly from Shepherd Center, the AURC and all individual usability projects must be reviewed by Shepherd Center's Institutional Review Board. This adds time and cost compared to commercial research companies, which do not have to adhere to review requirements for human-subjects protection. However, the requirement to define the study clearly and organize all the materials upfront ensures that studies are thoroughly considered, and all participants are properly protected including participant data privacy. The pace of product development at Microsoft can compete with careful research design.

This engagement with the IRB process has added to the AURC's original mission, which was solely to create the user network, recruit participants, and pay them for their participation. AURC staff regularly offer feedback and assistance in study design to the leaders of the individual studies at Microsoft, including guidance on what is feasible for human-subjects research review. Also, AURC staff assembles the package for the IRB amendment request for each study and manages all IRB communications. IRB review also means that AURC staff manages the participant consent process and maintains records.

## Operations

AURC operations have to address two contradictory forces: complexity and speed. Adapting the consumer network model of engagement of people with disabilities to the Microsoft-Shepherd Center partnership—something that Shepherd Center/RERC personnel managed as a purely internal operation—added complexity to operations. Meanwhile, adapting a model that was developed in an academic setting to that accelerated pace of a multinational ICT vendor imposed intensified productivity.

By design the AURC has numerous clients within Microsoft. For the program to be impactful and show value to sponsors within CELA, it needed to have a steady stream of projects, ideally from a broad set of product and business teams within Microsoft. In order to facilitate engagement with a variety of Microsoft teams, the AURC process for submitting requests for new projects and delivering the results had to be specified in detail. Table 1 shows the workflow for AURC usability projects.

***Table 1: AURC Usability Study Workflow***

| Stage | Description |
|---|---|
| Create request | Product teams fill out a short request form on SharePoint team collaboration tool AURC staff must check SharePoint account daily |
| AURC follow-up with requestor | AURC sends requestor an email to learn more details; often sets up conference call |
| Consultation on study design | AURC staff provides input/recommendations on study design to ensure collection of useful data to ensure approval by Shepherd Center IRB |
| IRB submission/approval | AURC assembles all documents for submission of amendment request to existing approved protocol for the entire program |
| Recruiting (often adding to AURC database) | Staff recruits people matching inclusion criteria from AURC database; if not enough individuals match criteria, new targeted recruiting is undertaken |
| Data collection | Much of the feedback data are collected via online questionnaires built in SurveyMonkey by AURC staff; other studies require online telephone interview or onsite in-person technology testing |
| Payment to participants | AURC staff pays participants stipends via Amazon gift cards or check request to Shepherd Center Financial Services |
| Reporting | Data need to be cleaned, anonymized, organized, and sent to project owner at Microsoft |
| Satisfaction surveys: Project leads and study participants | Satisfaction surveys sent to ensure quality of services to stakeholders and identify problems; results reviewed |

To date AURC has completed 14 use and usability studies of various types and has 3 additional studies currently underway. Projects have focused on specific Microsoft products (Windows, Office, Xbox, etc.) as well as general questions of how consumers with specific disabilities access and use technology. The disability focus of projects has varied, with many focusing on vision and hearing, and others focusing on cognitive and language processing difficulties.

## AURC Member Profile

In addition to conducting individual usability studies, AURC staff engage in ongoing general recruitment to the AURC network. Outreach efforts include use of social media channels, promotion at conferences like the California State University, Northridge (CSUN) Assistive Technology Conference (Lawrence & Morris, 2018) among others, and staff reaching out personally to their own contacts. Microsoft's CELA staff engage in extensive outreach to promote the AURC among disability organizations and internally within the company.

Recruiting new members to the national AURC network has been successful, with over 750 members. AURC staff dedicated considerable resources to general outreach efforts. Membership in the AURC network continued to grow as additional targeted recruiting for new usability projects was conducted. This "organic" growth of the AURC membership is beneficial to new members and the network overall, as it engages these new members in projects right away.

The current AURC membership has a mean age of 45.6 years with a standard deviation of 15.6 years. All recruitment communications and materials make it clear that one must be 18 years of age to be a member in the AURC and to participate in a usability study. The decision to include only legal adults was made to simplify the human subjects review process. The AURC may explore including adolescents going forward. The AURC broadly reflects the general population on other demographic variables, if not necessarily the population of people with disabilities, who tend to be less educated, and have lower income and employment (Table 2). In terms of race/ethnicity, a slightly higher percentage of AURC members are white/Caucasian than the general population. The racial/ethnic group most underrepresented is Hispanics/Latinos.

***Table 2: AURC Member Demographics (percentage of members)***

| | |
|---|---|
| Race/Ethnicity – White/Caucasian | 71.9 |
| Education – Bachelor's degree or higher | 62.6 |
| Income – Annual household income of $50,000 or higher | 44.5 |
| Employment – Full time or part time | 51.1 |

A very high percentage of the AURC membership reports difficulty seeing (58.4%). Another 29% report difficulty hearing (Table 3). These disabilities have been the focus of the majority of AURC usability studies to date, which may be driving in part their high representation among members. The survey allowed respondents to report more than one disability.

**_Table 3: AURC Member Disabilities (percentage of members)_**

| | |
|---|---|
| Seeing | 58.4 |
| Hearing | 29.1 |
| Walking or climbing stairs | 21.0 |
| Fatigue/limited stamina | 15.2 |
| Frequent worrying, nervousness, or anxiety | 14.0 |
| Using hands or fingers | 13.1 |
| Concentrating, remembering, or making decisions | 11.8 |
| Using arms | 9.6 |
| Speaking (so other can understand) | 6.3 |
| Learning, or learning disability | 6.1 |
| Sensory integration | 4.0 |
| Other | 5.4 |

Technology ownership and experience is often an inclusion criterion for the individual usability studies. The AURC intake questionnaire includes more than a dozen questions that map member technology profiles. The core question focuses on ownership of basic ICT platforms (Table 4). Not surprisingly, the most common devices are also the most versatile and mobile: smartphones (owned by 82.8% of members) and laptop computers (75%).

**_Table 4: AURC Member Technology Ownership Profile (percentage of members)_**

| | |
|---|---|
| Smartphone | 82.8 |
| Laptop computer | 75.0 |
| Tablet computer | 58.0 |
| Desktop computer | 53.0 |
| Specialized assistive technology | 21.9 |
| Smartwatch | 16.9 |
| Home automation | 15.3 |
| Fitness tracker or sensor | 14.4 |
| Home security system | 10.3 |
| Basic mobile phone | 6.5 |
| Other wearable technology | 5.8 |
| Home activity sensor | 3.4 |
| Sleep monitor | 3.7 |

## Satisfaction – Study Participants and Project Owners

A critical component of the AURC governance model is the conduct of satisfaction surveys for all study participants and for project owners at Microsoft, asking them: 1) to rate the overall experience; 2) whether they would recommend participating (or using, for project owners at Microsoft) the service; and 3) provide comments and suggestions. The two questions on ratings were on a Likert scale of 1-5 with 5 being best. A total of 190 individuals participated in one of the 14 completed usability projects and 108 completed the short satisfaction survey. As of June 30, 2018, 7 of the 14 project owners completed the satisfaction survey. Table 5 provides a summary of their responses.

Additionally, all 108 study participants said they would participate in another usability study. The studies are interesting to the participants and are not invasive or onerous. Participants also often are pleased when technology companies make the effort to get their feedback. It makes them feel their voice is being heard. Operationally, it is AURC policy to pay study participants by the end of the week in which they completed a study. Comments from participants reflected high levels of satisfaction with all of these aspects of the usability studies.

***Table 5: Satisfaction Scores for Study Participants and Project Owners***

| | Participants (n=108) | Project Owners (n=7) |
|---|---|---|
| Would you recommend AURC research to others? | 4.75 | 4.57 |
| How would you rate your overall experience? | 4.56 | 4.43 |

The project owners were also generally very pleased with AURC service, though a bit more critical than participants. While appreciative of the resources provided by CELA through the AURC, project owners would still prefer faster turnaround on projects. They are responsible for producing updates on a monthly or more frequent basis. However, even the simplest project with the least restrictive inclusion criteria (and, consequently, easiest recruiting) can take more than a month for development, IRB approval, recruiting, data collection, and delivery of results. In more academic environments this would be an impressive pace. At large, multinational IT vendors, it is often too slow. This is a challenge that will need continued attention to speed processes and to set expectations.

## Discussion

The AURC represents a distinct approach to engaging users with disabilities into the design process of Microsoft products. Its core features include the organization of a large national network of people with disabilities from which AURC staff recruits for specific, targeted user-needs and usability studies related to Microsoft products. It also builds on and supports user-centered design techniques, as well as the goals of Rehabilitation Engineering Research Centers (RERCs) and their funding agency, the National Institute on Disability, Independent Living and Rehabilitation Research (NIDILRR). The AURC model can be adopted by other research/advocacy organizations and other ICT vendors, but it requires operational and organizational agility and commitment by both organizations.

### User Centered Design, Usability, and Accessibility

The AURC contributes to a long tradition of user-centered design (UCD) which also finds expression in U.S. statutory law and regulatory policy. Jeffrey Rubin's seminal *Handbook of Usability Testing: How to Plan, Design, and Conduct Effective Tests* (1984) identifies 3 core principles of the UCD process: 1) early focus on users and tasks; 2) empirical measurement and testing of product usage; and 3) iterative design. Rubin also identifies four usability goals: 1) usefulness; 2) effectiveness (ease of use); 3) learnability; and 4) attitude (likeability).

UCD principles and goals are reflected in U.S. statutory law and regulation. The Americans with Disabilities Act (ADA) of 1990 prohibited discrimination in employment and access to places of public accommodation, services, programs, public transportation, and telecommunications. As information and communication technology (ICT) has grown in importance in our personal and professional lives, legislation and regulation to ensure accessibility and usability have followed. The Telecommunications Act of 1996 required that telecommunications services and equipment and "customer premises equipment” be "designed, developed, and fabricated to be accessible to and usable by individuals with disabilities, if readily achievable." The 1998 amendment to the Rehabilitation Act of 1973 required Federal agencies to make their electronic and information technology (EIT) accessible to people with disabilities.

In 2017, a final rule updating Section 508 of the Rehabilitation Act and Section 255 of the Telecommunication Act in response to market trends and innovations in technology was adopted (Information and Communication Technology (ICT) Standards and Guidelines, 2017). This “refresh” harmonized requirements with other guidelines and standards in the U.S. and internationally, including standards issued by the European Commission, and the World Wide Web Consortium (W3C) Web Content Accessibility Guidelines (WCAG 2.0).

The 2017 refresh includes a subsection on user needs (E203.2), stating: “When agencies procure, develop, maintain or use ICT they shall identify the needs of users with disabilities to determine:

A. How users with disabilities will perform the functions supported by the ICT; and
B. How the ICT will be developed, installed, configured, and maintained to support users with disabilities.”

Earlier, the 21st Century Communications and Video Accessibility Act of 2010 (CVAA) was adopted. CVAA is focused mainly on communications software and equipment manufacturers, video service providers, and producers of video content. The act requires that all communications and video programming be provided in an accessible manner to individuals with disabilities. It specifically references consultation with users to provide accessible communications and video technology solutions, including: “information about the manufacturer’s or provider’s efforts to consult with individuals with disabilities.”

The current consumer technology environment – proliferating ICT devices, cloud-based computing, intensifying competition among technological companies, and short update cycles for enhanced functionality, interoperability, and security – give greater urgency to UCD. These same forces also can pose substantial challenges to UCD. Continuous development and rapid updates match the UCD ideal of design and development as an ongoing iterative process. Yet, the tempo of development – particularly for software – challenges usability researchers to develop innovative processes to make consumer input timely. In today’s consumer technology development environment, UCD’s emphasis on being process-driven (e.g., Horton and Sloan, 2014) is especially well placed.

### AURC and the Mission of the National Institute on Rehabilitation, Independent Living, and Rehabilitation Research

The AURC and similar partnerships support the mission of centers funded by the National Institute on Rehabilitation, Independent Living, and Rehabilitation Research (NIDILRR) to:

> … generate new knowledge and to promote its effective use to improve the abilities of individuals with disabilities to perform activities of their choice in the community, and to expand society’s capacity to provide full opportunities and accommodations for its citizens

> with disabilities….by providing for research, demonstration, training, technical assistance and related activities, … promoting the transfer of, use and adoption of rehabilitation technology for individuals with disabilities in a timely manner; and ensuring the widespread distribution, in usable formats, of practical scientific and technological (NIDILRR, 2018).

NIDILRR's website also describes the purpose of the Rehabilitation Engineering Research Centers (RERCs):

> … to improve the effectiveness of services authorized under the Rehabilitation Act by conducting advanced engineering research and development of innovative technologies designed to solve particular rehabilitation problems or remove environmental barriers. RERCs also demonstrate and evaluate such technologies, facilitate service delivery systems changes, stimulate the production and distribution of equipment in the private sector, and provide training opportunities to enable individuals (including individuals with disabilities) to become researchers and practitioners of rehabilitation technology.

The LiveWell RERC is funded under one NIDILRR's four field-initiated funding areas focusing on Information and Communications Technology (ICT) Access. This was established in 2013 to: "…research, develop, and evaluate innovative technologies and strategies that will optimize accessibility and usability of one or more of the following: telecommunications products; wireless technologies; technology interfaces; computer systems; software; and networks for individuals with disabilities" (Federal Register, 2013).

The consumer network model for UCD is a strategy to optimize accessibility and usability of technology. NIDILRR funds do not support the AURC directly. However, the AURC is conceptually based on the Consumer Advisory Network model of user-centered research which has been developed and refined over the years by researchers at Shepherd Center with support from the NIDILRR-funded Wireless RERC and LiveWell RERC. This is an unanticipated outcome from NIDILRR's investment in the exploration and discovery, practical implementation, and knowledge creation related to this UCD model. Futhermore, it is highly impactful given the extensiveness of Microsoft's product and services portfolio, and the high number of Microsoft users worldwide.

## Prospects for Generalizing the AURC Model

Other research and advocacy organizations with expertise and interest in accessible and assistive technologies could adopt the AURC model. The fundamental requirement for any organization interested in forming their own user-centered research lab to support usability and usefulness of ICT products is agility. The AURC team's experience working with partners at large research institutions is that their administrative systems can be overly rigid and slow. Shepherd Center, by contrast, is relatively small with only 1500 employees overall, and about 50 working primarily in the research department. AURC staff scoped, gained IRB approval, and completed 14 individual usability projects in less than 12 months. The AURC paid 190 individual participant stipends, ranging from $25 to $150, for those projects. This high rate of production requires high levels of responsiveness on the part of supporting departments and review boards at the research institution.

For large ICT vendors, the key to success is to have a champion with a corporate-wide mandate to promote inclusive design and accessibility. Microsoft's Corporate and External Legal Affairs (CELA) group is that champion. It can provide the financial support for the AURC, promote AURC services to the company's numerous product and business teams, and help establish policies and procedures. Groups like CELA and its Accessibility Technical Evangelists act as key liaisons between the AURC and company product teams by providing deep knowledge of disability and accessibility as well as knowledge of corporate structure, processes, and initiatives.

### Ongoing Evolution of the Consumer Network Model for User-Centered Design

AURC staff, in consultation with CELA, has identified a number of challenges and opportunities for the program to continue to grow. First and foremost is setting expectations with product managers on project timelines, and finding ways to design projects that shorten timelines, perhaps dividing projects into multiple parts and delivering on the more straightforward components first.

Additionally, now that the AURC membership has grown to a substantial number, we need to find ways to communicate more systematically and meaningfully with the membership. The AURC maintains social media channels, but their effectiveness may be limited. Direct engagement seems to be more meaningful and rewarding to participants. The team created a quarterly newsletter as a way to continue to keep the membership engaged. Also, the AURC has launched additional research projects designed to engage the entire membership, including: 1) a survey on needs (fulfilled and not yet fulfilled) for accessibility and use of Microsoft products; and 2) the experiences with the first-ever joint national test of the Emergency Alert System (EAS) and Wireless Emergency Alerts (WEA) held on October 3, 2018. This test of the Presidential Alert offered a unique opportunity to engage AURC members of all ages and disabilities in a research project that was in the national news and affected the entire country.

Broader challenges involve adding new types of projects that the AURC supports. The original concept of the AURC was, at its simplest, to recruit study participants and pay them, and simultaneously build the larger network of people with disabilities. The scope of responsibilities has expanded due to institutional and stakeholder needs on both sides (e.g., IRB review processes at Shepherd Center; the extensive demand for consumer input at Microsoft). The breadth and complexity of usability projects is likely to grow, and the AURC will need to respond to new stakeholder needs. As the AURC embarks on its second year of activity, the project team, with the support of Microsoft's CELA group and various engineering product teams, has begun exploring the development of new structures and processes to speed the gathering of user feedback.

## Conclusion

The AURC has completed its first year of operation. The projects conducted had several positive impacts on products at Microsoft. The program increased the voice of the customer into design, engineering, and research at Microsoft, and created a scalable mechanism to implement inclusive design at Microsoft. The

AURC helped teams across the company prioritize accessibility work and provided feedback to build engineering roadmaps. Additionally, the AURC gave product teams more confidence that they were working on the right things and built more empathy for people with disabilities using Microsoft products.

For the ICT industry in general, the challenge of engaging consumers with disabilities is becoming ever more critical. Regulatory and technology imperatives related to compliance, reliability, interoperability, and accessibility will only grow more intensive. Additionally, as the populations of many countries grow older and as people with disabilities live longer lives, there will be even greater need for accessible and useful consumer technologies.

## Declarations

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