Department for Education

Rapid literature review on assistive technology in education

Research report

July 2020

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Executive Summary

Assistive technologies (AT) are specialised products designed for people with special educational needs and disabilities. This report summarises the available evidence concerning AT use and outcomes in education for policy makers, administrators, educators, researchers, and industry in order to provide a comprehensive snapshot of the evidence informing when, where, and for whom AT works.

Realising the potential of technology in education involves maximizing the application of assistive technologies to enhance academic, behavioral, social, and economic benefits of pupils and students with special educational needs and disabilities. When a person finds the appropriate AT, they are able to complete tasks that they previously could not complete, did slowly, or did poorly. The right AT augments, bypasses, or compensates for a disability. The design, marketing, and use of assistive technology must be understood in the context of technology used in education establishments (i.e. educational technology) as well as technology used in society (i.e. mainstream technology).

The focus of this rapid literature review was on gathering evidence from the academic databases, doctoral dissertations, and grey literature (i.e., non-indexed journals, conference papers, and technical reports) from the years 2005 to 2019. The goal was to understand both the state of the art (as reflected in literature for practitioners), and the state of the science (as reflected in peer-reviewed research literature), concerning AT use and the outcomes and benefits experienced by pupils and students with SEND. The review focused on evidence in four English-speaking countries: Australia, Canada, United Kingdom, and the United States

The findings of this rapid review of the AT literature revealed a knowledge base of over 950 documents of which 96 were literature reviews. 30 evidence reviews provide moderate – strong evidence concerning the efficacy of specific applications of AT.

Disabilities manifest themselves in many different forms and severities. To discern where, when, how, and for whom AT works we need to understand both the depth of research within specific disability categories as well as the breadth of technologies that support core functioning. This rapid review provides evidence regarding AT applications for all special needs and disabilities at all levels of the educational system. The most research validated AT intervention focuses on speech, language, and communication disabilities and the use of communication systems known as augmentative and alternative communication (AAC) devices. This body of research evidence is strong and exceedingly clear: providing individuals with a method of communicating, the earlier the better, improves a variety of outcomes relative to independence, educational outcomes, and quality of life.

One of three models are commonly used in education establishments to organise AT services: (1) *Historical*: AT is a component of special education services; (2) *Inclusive*: AT has been elevated by school and college leadership who set priorities for inclusive education or multi-tier support systems (MTSS) where the general education classroom is viewed as the home unit for all students with a goal of making differences ordinary; and (3) *Universal Usability*: All school and college personnel work intimately together to procure universally accessible technologies (that is, accessible out of the box: accessibility features are built-into products that just need to be turned on as needed). In this model, there is no longer a single accessible computer station in the classroom or library, but rather, all computer workstations are fully accessible and a student can use any computer. Advocacy for accessible educational materials (AEM) is a necessary component of AT devices and service systems. The importance of AEM cannot be underestimated during the COVID-19 pandemic and the shift to online instruction where pupils and students with special needs and disabilities have experienced (1) barriers in online learning management systems, (2) multimedia, web pages, and/or documents that are not accessible, and (3) barriers within teaching activities because they do not have the appropriate AT devices and services to access the curriculum.

At this time, AT is an under-utilised intervention to provide pupils and students with special needs and disabilities a means for accessing and engaging in the curriculum in ways that are representative of the ubiquitous nature of technology in society. As a first course of action, let us be mindful that advances in *universal usability* have provided access tools on every smartphone, computer tablet, laptop, and desktop computer. Parents and educators are encouraged to explore the accessibility features on their devices as a critical first step in locating appropriate AT to help a struggling student. Realising the potential of assistive technology will require the coordinated efforts of students, parents, educators, administrators, policymakers, developers, service providers, and researchers to scale the number of pupils and students benefitting from AT interventions that have been shown to be effective.

1.0 Introduction

Assistive technologies (AT) are specialised products designed for people with special educational needs and disabilities (SEND). This report summarises the available evidence concerning AT use and outcomes in order to provide a comprehensive snapshot of the evidence informing when, where, and for whom AT works in educational settings.

1.1 Context: Realising the Potential

The Department for Education's Educational Technology Strategy, *Realising the Potential for Technology in Education*[1] defined 10 EdTech Challenges designed to catalyse activity in specific areas of the Educational Technology sector. One challenge focused on the need to identify the best technologies to help level the playing field for pupils and students with Special Educational Needs and Disabilities:

> Challenge 6: Challenge the research community to "identify the best technology that is proven to help level the playing field for learners with special educational needs and disabilities" (p. 33).

Why Support Technologies to Level the Playing Field?

The right AT augments, bypasses, or compensates for a disability. Whereas all people use technologies to interact with the world, Layton and colleagues[2] contend that AT is essential for fostering people's right to be treated fairly, enabled to participate in inclusive communities, and supported to reach desired outcomes. Berry[3] observes, "fairness, with respect to inclusion, means that all students receive the supports or instruction they need to achieve academically, not that all students receive the same supports or instruction" (p. 1150). The United Nations Convention on the Rights of Persons with

[1] Department for Education. (2019). Realising the potential for technology in education. Retrieved from https://www.gov.uk/government/publications/realising-the-potential-of-technology-in-education

[2] Layton, N., Hubbard, W., Burton, J., & Kuna, A. (2016). Quality, choice and outcomes in assistive technology (AT) equipment funding schemes: A procurement case study. *Health Systems and Policy Research, 3*(1), 1-8.

[3] Berry, R. A. W. (2008). Novice teachers' conceptions of fairness in inclusion classrooms. *Teaching and Teacher Education, 24*(5), 1149-1159.

Disabilities (2006)[4] has afforded AT the status of a human right. For this reason, ratifying countries commit to facilitating access to AT solutions for those who need them in order to foster participation in democratic society on an equal basis with others and improve independence in daily life. Therefore, AT should be viewed as a strategic investment in pupils and students with special educational needs and disabilities to ensure that they have the opportunities necessary to access, engage, and benefit from their educational experience and move beyond historical barriers that limit their potential.

1.2 Why are Pupils and Students with Special Educational Needs and Disabilities (SEND) at a Disadvantage?

In England, in January 2019, the number of pupils with special educational needs (SEN) has increased for a third consecutive year to 1,318,300, representing 14.9% of the total pupil population.[5] Realising the potential of technology in education involves maximising the application of assistive technologies to enhance academic, behavioral, social, and economic benefits of pupils and students with special educational needs and disabilities.

Historically, pupils and students with special educational needs and disabilities have had difficulty accessing the general education curriculum. This means they have been unable to achieve the same benefits from instruction as their peers. Furthermore, difficulties in accessing and engaging with educational materials and instruction approaches often resulted in educational achievement that was below their potential. Cumulatively, poor Stage 1-4 educational outcomes subsequently limit post-secondary employment and further education.[6] Policy initiatives and investments in assistive technology have the potential to reverse the historical disadvantages experienced by pupils and students with special educational needs and disabilities in ways that improve opportunities.

1.3 What is Assistive Technology (AT)?

The World Health Organization[7] describes AT as follows:

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[4] United Nations. (2006). *Convention on the rights of people with disabilities*. NY: Author. Available at: https://www.un.org/development/desa/disabilities/convention-on-the-rights-of-persons-with-disabilities.html

[5] Special Educational Needs in England: January 2020. Retrieved from https://www.gov.uk/government/statistics/special-educational-needs-in-england-january-2019

[6] Chatzitheochari, S., & Platt, L. (2019). Disability differentials in educational attainment in England: Primary and secondary effects. *The British Journal of Sociology, 70*(2), 502-525.

[7] World Health Organization. (2018, May 18). Assistive technology. Retrieved from https://www.who.int/news-room/fact-sheets/detail/assistive-technology

> Assistive technology is an umbrella term covering the systems and services related to the delivery of assistive products and services.
>
> Assistive products maintain or improve an individual's functioning and independence, thereby promoting their well-being.
>
> Assistive technology enables people to live healthy, productive, independent, and dignified lives, and to participate in education, the labour market and civic life. Assistive technology reduces the need for formal health and support services, long-term care and the work of caregivers. Without assistive technology, people are often excluded, isolated, and locked into poverty, thereby increasing the impact of disease and disability on a person, their family, and society.

de Witte and colleagues[8] elucidate the definition and purpose of AT by foreshadowing the complexities between the intentional advocacy of AT policy and the localised practices associated with identifying the "right" AT for an individual:

> Assistive technology (AT) is an umbrella term for products and related services used by persons with disability to enable and enhance their inclusion in all domains of participation. AT can be used by people of all ages and with all types of impairment (loco-motor, visual, hearing, speech or cognition) and all sorts of limitations in activities, and for short or long periods of time. The combination of products and strategies to meet an individual's needs is called an "AT solution," and is developed via processes of assessment, trial and adaptation. Some AT solutions are simple and require low-tech devices, others are very expensive and complex. This variety of user groups and the wide range of assistive products and related services make the provision of AT a complex issue. This complexity is further increased by the fact that the impact of a particular AT solution depends largely on the aspirations and individual characteristics of the user. There is not one AT solution that fits all; what works for one user might not work at all for another (p. 467).

1.4 Why is AT Important?

Over a lifetime, each of us will experience situations in which we personally, or, someone we know, will encounter limitations due to aging, disease, accident, or disability, that will impact the ability to perform basic life functions such as hearing, seeing, self-care, mobility, working, and participating in education. Whereas some of us may be born with a disability or disease that will require us to overcome limitations throughout our life, others will need to learn how to respond to challenges that arise from an accident or limitations that arise from simply growing older. As a result, AT has the potential to impact everyone, either directly as a personal user of AT, or indirectly, as a means of helping someone we know.

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[8] de Witte, L., Steel, E., Gupta, S., Ramos, V. D., & Roentgen, U. (2018). Assistive technology provision: Towards an international framework for assuring availability and accessibility of affordable high-quality assistive technology. *Disability and Rehabilitation: Assistive Technology, 13*(5), 467-472.

The value and significance of AT can be understood in relation to performance problems. That is, a person with a disability encounters a task they are unable to successfully complete. Following the identification of an appropriate assistive technology device, acquisition of the product, training and support in its use, a person is subsequently able to use their AT to complete the same task that was previously difficult or impossible. When appropriate assistive technology devices and services are provided, an individual is able to complete tasks more effectively, efficiently, and independently than otherwise possible without the tools.

The Need for Technology

For most of us, technology makes things easier. For a person with a disability, it makes things possible. – Judy Heumann, Educational Policymaker

2.0 Methodology

A *rapid review*, sometimes referred to as a *scoping review*, is a process of systematically mapping a body of literature in order to produce information in an expedited timeframe.[9] The intent of a rapid review is to engage in a broad search to gather as many types of documents as possible concerning the topic of interest. Subsequent analysis focuses on identifying the key concepts, theories, sources of evidence, and gaps in the research in order to contextualise the knowledge.

This rapid review literature project was conducted over a ten-week period beginning in February 2020. The activities involved gathering, reviewing, and synthesising the existing research evidence from the period of 2005 through 2019 concerning the use and effectiveness of assistive technology (AT) by pupils and students with special educational needs and disabilities (SEND). This chapter provides a brief overview of the methodologies used by the project. Readers interested in the technical details of this work are encouraged to consult the companion web site (https://www.knowledge-by-design.com/ukat/).

2.1 Theoretical Framework

The design, marketing, and use of assistive technology must be understood in the context of technology used in education (i.e. educational technology) as well as technology used in society (i.e. mainstream technology). The theoretical framework for the project is illustrated in Figure 1.

The theoretical framework is foundational for the research given that a specific technology may or may not be labelled as *assistive technology* since the function of all technology is to function as a tool that extends the user's performance. Second, since many pupils and students with special educational needs and disabilities are served in *inclusive classrooms*, it is necessary to understand the general technologies they may encounter in these environments. Finally, since mainstream technologies increasingly incorporate universal design for learning (UDL) principles into product design, some

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[9] Dobbins, M. (2017). *Rapid review guidebook steps for conducting a rapid review*. Hamilton, Ontario, Canada: National Collaborating Centre for Methods and Tools. Retrieved from https://www.nccmt.ca/capacity-development/rapid-review-guidebook

Guise, J. M. (n.d.). Rapid review guidance document. Rockville, MD: Agency for Healthcare Research and Quality. Retrieved from https://www.ahrq.gov/sites/default/files/wysiwyg/funding/contracts/epc-vi/22-rapid_evidence_products_guidance.pdf

Lockwood, C., dos Santos, K. B., & Pap, R. (2019). Practical guidance for knowledge synthesis: Scoping review methods. *Asian Nursing Research, 13*, 287-294.

Tricco, A. C., Antony, J., Zarin, W., Strifler, L., Ghassemi, M., Ivory, J., ... & Straus, S. E. (2015). A scoping review of rapid review methods. *BMC Medicine, 13*, article 224, 1-15.

functions that formerly required specialised assistive technology can now be found in off-the-shelf products such as laptop, tablet, and smartphone operating systems and web browsers.

Figure 1
Understanding Assistive Technology in the Context of Technology used in Education and Society

2.2 Research Questions

The purpose of this study was to investigate the following three primary research questions:

#1: What are the characteristics of the assistive technology evidence base?

#2: What is presently known about assistive technology use by pupils and students with special educational needs and disabilities (SEND)?

#3: What is most effective when it comes to AT implementation and use?

Each question will be examined in detail in a subsequent chapter.

2.3 Scope

The scope of the project was operationalised using the parameters outlined in Table 1. In summary, the project focused on gathering evidence from the academic databases, doctoral dissertations, and grey literature (i.e. non-indexed journals, conference papers, and technical reports) from the years 2005 to 2019. The goal was to understand both the

state of the art (as reflected in literature for practitioners), and the state of the science (as reflected in peer-reviewed research literature), concerning AT use and the outcomes and benefits experienced by pupils and students with SEND. The review focused on evidence in four English-speaking countries: Australia, Canada, United Kingdom, and the United States because of the similarity of their educational systems; economies; and commitment to diversity, equity, and inclusion.

Table 1 Project Parameters

Parameter	*Variables*
Period	• source materials published from 2005 through 2019
Language	• source materials must be available in English
Format	• source materials must be available in full-text format
Localisation	• source materials must be from Australia, Canada, the United Kingdom, or the United States
Exclusionary Content	• blog entries • book reviews • editorials and special issue introductions • program/product profiles [adverts, reviews, profiles]
Exclusionary Exceptionalities	• gifted and talented students • other health impaired
Exclusionary Technologies	• cochlear implant; hearing aids • eyeglasses • wheelchairs; seating and positioning

2.4 Data Sources

Seven commercial literature databases were identified as indexing literature relevant to research and practice concerning assistive technology: Academic Search Complete, CINAHL Plus, Education Research Complete, Educational Resources Information Center, MedlinePlus, PsycINFO, and Web of Science.

2.5 Search Constructs

AT is not a single unidimensional construct. The 22 different search terms used in this study reflect the diversity of the AT discipline such that there are broad concepts of interest (e.g. AT assessment, AT outcomes) as well as specific types of special needs and disabilities (e.g. specific learning disability). Table 2 summarises two groups of search constructs that were used to operationalise the literature searches: (1) disability constructs, and (2) assistive technology constructs. The core terms were implemented with appropriate wild cards to ensure that multiple forms of the key words were found (i.e. dis* retrieves both disability and disabilities).

Table 2 Search Constructs

Construct	***UK Variables***	***US Variables***
Disability (RQ2)	specific learning difficulty	specific learning disability
	moderate learning difficulty	specific learning disability intellectual disability
	severe learning difficulty	specific learning disability intellectual disability
	profound and multiple learning difficulty	intellectual disability
	social, emotional and mental health	emotional/behavioral disturbance
	speech language and communication needs	Speech or language impairment
	hearing impairment	hearing impairment (including deafness)
	visual impairment	visual impairment (including blindness)
	multi-sensory impairment	deaf-blindness traumatic brain injury
	physical disability	physical disability
	autistic spectrum disorder	autism
Construct	**Variables**	**Exemplars**
Assistive Technology (RQ3)	AT advocacy	advocacy, AT child find, awareness, transitions
	AT assessment	need for AT, assessment, trialing, evaluation, selection, accessibility, usability
	AT decision-making	AT consideration, AT teams, IEP team
	AT devices	products considered to be AT
	AT services	services, supports
	AT outcomes	abandonment, efficacy of AT systems, benefits, AT & employment, quality indicators, measurement, instrument development, return on investment, stigmatisation, user satisfaction
	AT personnel	AT certification, licensure, competencies, ethics, knowledge and skills, personal preparation (pre-service and in-service)
	AT policy	AT laws, court rulings, legal analysis, policy statements, standards
	AT research and development	cloud-based AT, development, evidence reviews, innovation,

		Internet of Things (IoT), AT & machine learning, new product development
	Service Delivery: AEM	access to the curriculum, accessible educational materials (AEM), accessible instructional materials (AIM)
	Service Delivery: UDL	access for all, universal accessibility, universal design, universal design in education, universal design for learning, universal usability
	AT Theory	theoretical frameworks

2.6 Search Processes

The literature search process was conducted in the following sequence in order to (a) determine whether additional modifications to the search protocol would be necessary before scaling the process, and (b) to facilitate the management of search results that were likely to return similar types of documents within a cluster. The Principal Investigator conducted each of the searches in clusters 1-5 and the Project Coordinator conducted the searches in clusters 6-7.

Cluster #1: traumatic brain injury
Cluster #2: sensory impairments (visual impairment, blindness, hearing impairment, deafness)
Cluster #3: developmental disabilities (autism, intellectual disabilities, physical disabilities)
Cluster #4: high-incidence disabilities (emotional/behavioral disorders, learning disabilities, speech language and communication)
Cluster #5: AT constructs (see list in Table 2)
Cluster #6: grey literature
Cluster #7: doctoral dissertations

The numeric results of each search were recorded on a worksheet. Each item was visually scanned to determine whether or not the entry met the inclusion criteria. If the item was initially deemed as meeting the inclusionary criteria, efforts were made to secure a PDF copy of the document. In a majority of the cases, this was readily available through the academic databases from two university libraries. In other cases, it meant connecting to the journal web site to locate a copy. In situations where the documents were considered potentially important, but apparently unavailable (e.g. embargoed), a request for the article was made through a university inter-library loan service who achieved a 100% success rating in obtaining the document within 1-10 days.

To build a citation base for the project, the title of each relevant document was entered into Google Scholar to obtain the APA formatted citation. In many cases, the Google citation contained errors that needed to be manually corrected or missing information that needed to be located (e.g. conference proceedings, volume/issue). The full citation was then saved in a topical file as well as in the master project database.

After the document citation was recorded, the *Cited by* button within Google Scholar was utilised to identify potentially other relevant works (e.g. connected to the target article by the fact that it cited this previous work). This technique, known as *forward chaining*, provided clear evidence about the impact of a found article by recording the number of subsequent citations to the document as well as the impact of the future works on the topic. Needless to say, this process was very time consuming and involved a good deal of discretion to determine the value-add of including more recent publications on a topic and when to cease the process.

Each relevant document was identified using the naming convention: lastnameYEAR.pdf and saved in a topical folder, a master document folder, and a cloud-based storage system to ensure the redundancy and security of the data. In addition, each PDF was entered into a reference citation management tool to provide the research team with full-text indexing of each word within every document as well as access to real-time statistics about the citation count, links to other articles that have cited the work, and more.

Each document was reviewed by the project staff and coded using a pre-defined set of metadata. Every document, and its metadata, were reviewed by the Principal Investigator when data for each document were entered into the master database. The full-text database of documents and project database of citations and metadata were used to compile the final report. By the conclusion of the project, 968 documents were identified for analysis. Readers interested in exploring the data set are encouraged to visit the companion web site (https://www.knowledge-by-design.com/ukat/) to conduct their own topical searches in a web-based version of the dataset.

2.7 Limitations of the Study

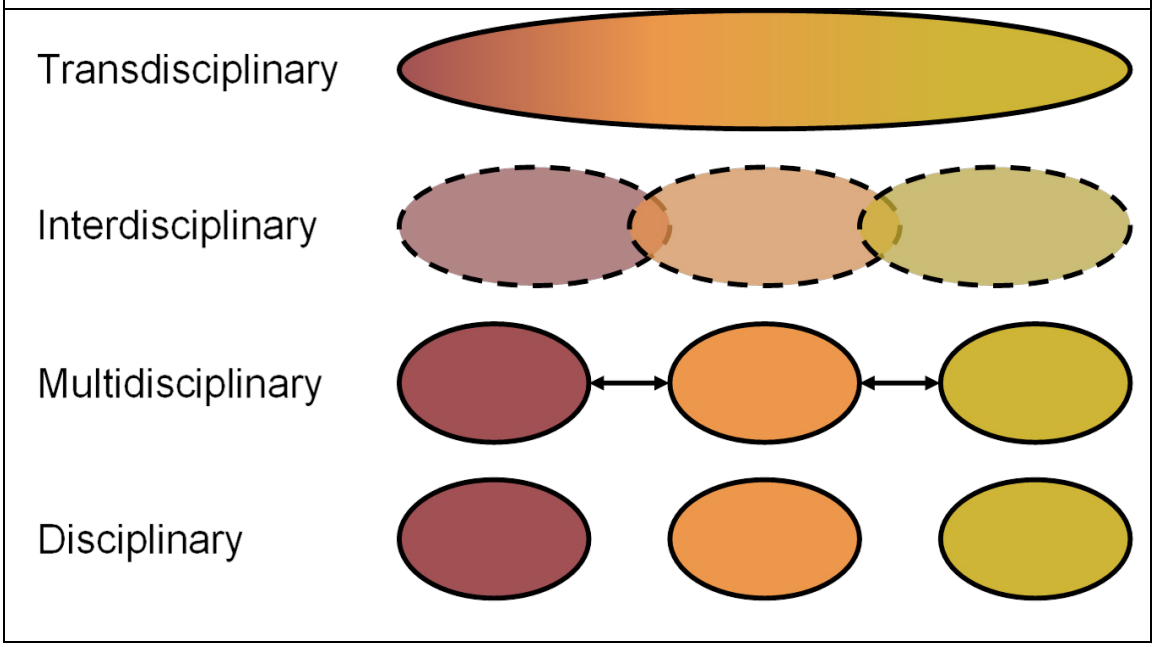
Given that the purpose of a rapid review of the literature is to explore a large body of literature over a short period of time, the fundamental task requires the researcher to reconcile *precision* (that is, how useful the search results are) vs. *recall* (that is, how complete the results are) within the constraints of time, human energy, and analytic power. Therefore, while a significant body of literature was identified in this study, it is highly probable that key documents were overlooked. Furthermore, given that the majority of project effort focused on locating and capturing relevant documents, the time available for analysis was significantly constrained. Therefore, there is much more to be learned from this dataset.

Interested readers are encouraged to contact the Principal Investigator Dave Edyburn, Ph.D, (edyburn@uwm.edu) to explore collaborations that may uncover patterns still hidden within the corpus.

3.0 What are the Characteristics of the AT Evidence Base?

As a transdisciplinary profession (see Figure 2), the literature on AT can be found within and across disciplines such as special education, occupational therapy, rehabilitation, speech and language, educational technology, higher education, and more. As such, it may be important to keep in mind the parable of the blind men who encounter an elephant and draw vastly different conclusions about the nature of the beast from their limited experience. The findings of this rapid review of the AT literature reveal that the knowledge base is large, scattered, and growing. As a result, the parable may explain many different interpretations about the state of AT practice in education based on what is commonly believed versus what has been established through high-quality research that has yet to be fully assimilated by the profession.

Figure 2
Comparison of Disciplinary Relationships and Integration



3.1 Size of the Knowledge Base

The search and review process resulted in a corpus of 968 articles that form the basis of the corpus for this AT rapid review report. Table 3 illustrates the number of found articles by year. It should be noted that the 2019 article total is artificially inflated as prepublication preprints, labeled as 2019, will receive a new copyright date when published in 2020 or beyond. The sheer size of the knowledge base foreshadows the significant challenge stakeholders will experience in trying to stay up-to-date within this discipline.

Table 3 Search Results of Key Terms Within the Article Title															
year	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19
	26	27	37	42	54	59	62	65	62	79	71	76	89	95	124

Table 4 illustrates the number of articles found by disability. Some disability categories are low incidence which is reflected in the smaller number of articles found (e.g. deaf-blindness). In other cases, there is extensive research interest in disabilities such as autism, intellectual disabilities, and speech language communication. Somewhat problematic is the under-representation of a high incidence disability, like learning disabilities, not having a more substantial AT literature basis.

Table 4 Articles Found by Disability Category		
Disability	***Number of Articles***	***Percentage of the Total Corpus***
Autism	77	13%
Deaf-blindness	10	1.7%
Emotional/behavior disorders	9	1.5%
Hearing impairment	27	4.5%
Intellectual disabilities	71	12%
Physical Disabilities	85	14.3%
Learning disabilities	81	13.6%
Speech language	125	21%
Traumatic brain injury	16	2.7%
Visual impairments	93	15.7%
Total	594	100%

Table 5 illustrates the number of articles found by AT construct. As noted earlier, AT is not a single unidimensional construct. The search terms used in this study reflect the diversity of the AT discipline such that there are broad concepts of interest (e.g. AT assessment, AT outcomes) as well as specific types of special needs and disabilities (e.g. specific learning disability). The sheer size of the classification of AT advocacy represents a coding artifact as this descriptor was used to code articles advocating a particular application of AT without scientific evidence on its efficacy (e.g. how-to practitioner articles).

Table 5 Articles Found by AT Construct

Construct	*Number of Articles*	*Percentage of the Total Corpus*
AT advocacy	305	31.5%
AT assessment	53	5.5%
AT decision-making	32	3.3%
AT devices	25	2.6%
AT outcomes	142	14.7%
AT personnel	109	11.3%
AT policy	33	3.4%
AT R&D	109	11.3%
AT services	49	5%
Accessible educational materials	61	6.3%
Universal design for learning	50	5.1%
Total	968	100%

3.2 Characteristics of the Corpus

Several characteristics of the corpus are worth noting. Table 6 illustrates the contribution of articles by country and reflects the dominance of United States authors and journals in the AT literature. However, given the economic and educational similarities of the four target English-speaking countries, the corpus appears to have relevant cross-cultural application.

Table 6 Documents Included in the Corpus by Country

Country	*Number of Articles*	*Percentage of the Total Corpus*
Australia	33	3.5%
Canada	53	5.5%
United Kingdom	44	4.5%
United States	743	76.7%
Other	95	9.8%
Total	968	100%

A second attribute of the corpus reflects the types of documents collected. The purpose of a rapid review was to cast a wide net, to discover not only peer-reviewed journal articles, but also grey literature that could take the form of articles for practitioners, book chapters, conference proceedings, doctoral dissertations, and reports/whitepapers. Table 7 summarises the types of documents collected by this project for review and analysis. The variety of dissemination outlets used in the field of AT is compatible with calls for diversifying the inputs associated with evidence reviews.[10]

[10] Giustini, D. (2019). Retrieving grey literature, information, and data in the digital age. In, H. Cooper, L.V. Hedges, & J.C. Valentine, (Eds.). *The handbook of research synthesis and meta-analysis* (pp. 101-126). NY: Russell Sage Foundation.

Table 7 Types of Documents in the Corpus		
Article Type	***Number of Articles***	***Percentage of the Total Corpus***
Article - Practitioner	320	33.1%
Article - Refereed Journal	455	47%
Book Chapter	23	2.4%
Cochrane Review	1	0.0%
Conference Proceedings	42	4.3%
Doctoral Dissertation	110	11.4%
Report/Whitepaper	17	1.8%
Total	968	100%

Early work on synthesising the special education technology literature discovered that the published literature focused more on how-to practice than research-based practice.[11] While the current study discovered a significant body of practitioner-focused literature, there are clear patterns that more research has been conducted, and that over time, greater attention has been placed on efforts to critically analyse the literature to establish the efficacy of various interventions and professional practices (see Table 8). However, at this point it is difficult to describe the field of AT as an evidence-based profession given that only 10% of the literature focuses on research evidence for its interventions and practices.

[11] Edyburn, D.L. (2000). 1999 in review: A synthesis of the special education technology literature. *Journal of Special Education Technology, 15*(1), 7-18.

Table 8 Types of Literature Reviews in the Corpus		
Review Type	***Number of Articles***	***Percentage of Literature Reviews***
Cochrane reviews	1	1.0%
Systematic reviews	35	36.5%
Meta analyses	8	8.3%
Descriptive reviews	45	46.9%
Scoping reviews	7	7.3%
Total	96	100%

3.3 Literature Scatter

The current study found that six publications form a core of the AT literature that resulted in a capture rate of 54% of the documents discovered (see Table 9). Practically, this finding has important implications for libraries, resource centers, and professionals interested in creating a specialised collection for studying and monitoring a significant portion of the new annual contributions to the AT knowledge base. Technically, however, it should be noted that the data are skewed given the search methods that captured all of the articles in the grey literature (i.e. *AT Outcomes and Benefits*, *Closing the Gap*, doctoral dissertations) versus the other peer-reviewed journals that were discovered as a result of key word searching. For readers interested in international applications of AT, two journals on this list may be of particular interest: *Disability and Rehabilitation: Assistive Technology*; and *Technology and Disability*.

Table 9 Publications that Form a Core of AT Literature		
Publication	***Number of Articles Included***	***Percentage of the Total Corpus***
Closing the Gap	292	30.2%
AT Outcomes and Benefits	68	7.0%
Disability and Rehabilitation: Assistive Technology	47	4.9%
Journal of Special Education Technology	28	2.9%
Assistive Technology	72	7.4%
Technology and Disability	18	1.8%
Total	525/968	54.2%

3.4 Quality of the Evidence Supporting AT Use

Whereas a rapid review typically only aggregates the documents into a descriptive summary, efforts were made to produce a preliminary assessment of the quality of the evidence found in each document. Two types of codes were assigned to each document to represent the quality of evidence presented. The first code was a numeric assignment, based on a 7-point scale, based on a preliminary analysis by the Principal Investigator to provide a weight that could be used regarding the quality of evidence (see Table 10). This type of coding is commonly used in evidence reviews but is problematic in this study because of the inadequate in-depth analysis applied to each found document that could results in classification errors.

Table 10 Evidence Quality			
Level	***Description***	***Number of Documents***	***Percentage of the Total Corpus***
1	A systematic review or meta-analysis with effect sizes	15	1.5%
2	Evidence obtained from at least one well-designed RCT (e.g. large multi-site RCT)	9	1.0%
3	A well-designed controlled trial without randomisation	0	0%
4	A well-designed experiment, case-control, or cohort study	8	1.0%
5	A systematic review	74	7.6%
6	Data from a single research study	330	34.0%
7	Opinion of authorities and/or reports of expert committees (non-data based)	532	54.9%
	Total	968	100%

Since the coding in Table 10 requires a level of technical analysis to apply and use, this information will have limited value to the majority of stakeholder groups who lack the technical and statistical background to discern the differences among the levels of evidence. Therefore, a three-point scale (see description in Table 11) is commonly used to help practitioners apply research evidence.[12]

[12] What Works Clearinghouse. (2020). *Practice guides*. Washington, DC: Author. Retrieved from https://ies.ed.gov/ncee/wwc/practiceguides

Table 11 Quality of Evidence as Described in Educational Policy

Tier	*Level*	*Description*
1	Strong	Evidence from at least 1 well-designed and well-implemented experimental study.
2	Moderate	Evidence from at least 1 well-designed and well-implemented quasi-experimental study.
3	Promising	Evidence from at least 1 well-designed and well-implemented correlational study with statistical controls for selection bias.
4	Demonstrates a Rationale	Based on high-quality research findings or positive evaluation of likelihood to improve student outcomes or other relevant outcomes; and includes ongoing efforts to examine effects.

In order to make the results meaningful to a wide variety of stakeholders, a second evidence code was assigned to each document (see Table 11). The recoding of the evidence on the three-point scale (emerging, moderate, or strong), or for non-databased works (demonstrates a rationale), should facilitate the use of evidence by the majority of stakeholder groups who have limited interest in the technical and statistical differences among the levels of evidence.

As illustrated in Tables 10 and 12, expert opinion (i.e. demonstrates a rationale), explaining how/why AT can be used, is a function of more than half (54.9%) of the AT literature. Then, considering the contribution of individual studies, (34.0%), it is clear that the research evidence is a very small component (10.9%) of the professional literature limiting the application of research-based evidence for informing efforts to scale AT interventions. Nonetheless, the corpus of 96 literature reviews with 30 moderate – strong evidence reviews offers an informative body of research for answering the additional research questions posed within this study.

Table 12 Descriptive Evidence Level			
Descriptor	***Evidence Level***	***Number of Documents***	***Percentage of the Total Corpus***
Strong	Levels 1-2	24	2.4%
Moderate	Levels 3-4	8	0.1%
Emerging	Levels 5-6	404	41.7%
Demonstrates a rationale	Level 7	532	54.9%
	Total	968	100%

3.5 Conclusions: AT Evidence Base

The following overall conclusions are drawn concerning the nature of the AT evidence base circa 2020:

- At this time, only a small number of AT interventions can be documented as having a moderate or strong evidence base. This finding, within the context of a rapid review of the literature study, is congruent with previous AT evidence synthesis reviews.[13]

- The most research validated AT intervention focuses on speech, language, and communication disabilities and the use of communication systems such as augmentative and alternative communication (AAC) devices. The research evidence is strong and exceedingly clear: providing individuals with a method of communicating, the earlier the better, improves a variety of outcomes relative to independence, education outcomes, and quality of life.[14]

[13] Anttila, H., Samuelsson, K., Salminen, A. L., & Brandt, A. (2012). Quality of evidence of assistive technology interventions for people with disability: An overview of systematic reviews. *Technology and Disability, 24*(1), 9-48.

[14] Dunst, C. J., Trivette, C. M., Hamby, D. W., & Simkus, A. (2013). Systematic review of studies promoting the use of assistive technology devices by young children with disabilities. Practical Evaluation Reports, 5(1), 1-32. Asheville, NC: Orelena Hawks Puckett Institute. Morin, K. L., Ganz, J. B., Gregori, E. V., Foster, M. J., Gerow, S. L., Genç-Tosun, D., & Hong, E. R. (2018). A systematic quality review of high-tech AAC interventions as an evidence-based practice. *Augmentative and Alternative Communication, 34*(2), 104-

- Improved tools and protocols for evaluating and grading the quality of AT primary research studies are consistently mentioned in evidence reviews as a critical need for the AT profession.[15]

- The overall level of evidence concerning the effectiveness of AT is generally low because most primary studies have methodological limitations (e.g. insufficiently powered research designs, small numbers of subjects, inadequate descriptions of participants' functional limitations and/or the study contexts, inadequate attention to reporting effect sizes and the confidence intervals of the observed changes). Resolving these issues will take concerted efforts by researchers, journal editors, and reviewers to apply evidence standards when judging the publication worthiness of new research studies.[16]

Additional implications of the evidence base will be explored in the next chapter regarding what is presently known about AT use in educational settings by pupils and students with special educational needs and disabilities.

117. Romski, M., Sevcik, R. A., Barton-Hulsey, A., & Whitmore, A. S. (2015). Early intervention and AAC: What a difference 30 years makes. *Augmentative and Alternative Communication, 31*(3), 181-202.

[15] Anttila, H., Samuelsson, K., Salminen, A. L., & Brandt, A. (2012). Quality of evidence of assistive technology interventions for people with disability: An overview of systematic reviews. *Technology and Disability, 24*(1), 9-48. Morin, K. L., Ganz, J. B., Gregori, E. V., Foster, M. J., Gerow, S. L., Genç-Tosun, D., & Hong, E. R. (2018). A systematic quality review of high-tech AAC interventions as an evidence-based practice. *Augmentative and Alternative Communication, 34*(2), 104-117. Muharib, R., & Alzrayer, N. M. (2018). The use of high-tech speech-generating devices as an evidence-based practice for children with autism spectrum disorders: A meta-analysis. *Review Journal of Autism and Developmental Disorders, 5*(1), 43-57.

[16] Scherer, M., Smith, R. O., & Layton, N. (2019). Committing to assistive technology outcomes and synthesizing practice, research and policy. In N. Layton, & J. Borg, (Eds.), *Global perspectives on assistive technology: Proceedings of the GReAT Consultation 2019, Volume 1* (pp. 196-217). Geneva, Switzerland: World Health Organization. Williamson, T., Kenney, L., Barker, A. T., Cooper, G., Good, T., Healey, J., ... & Ryan, J. (2015). Enhancing public involvement in assistive technology design research. *Disability and Rehabilitation: Assistive Technology, 10*(3), 258-265.

4.0 What is Presently Known about AT Use in Educational Settings?

Disabilities manifest themselves in many different forms and severities. To discern where, when, how, and for whom AT works we need to understand both the depth of research within specific disability categories as well as the breadth of technologies that support core functioning. Previous research has demonstrated that some disabilities are under-represented in the special education technology research literature (i.e. blindness, specific learning disabilities) while some disabilities like intellectual disabilities and speech, language, and communication disorders have a robust research base.

The essence of assistive technology involves finding appropriate tools that enhance the functional performance of a person with a disability to complete routine tasks that are difficult or impossible. The magnitude of this task is not insignificant as there are over 25,000 assistive technology devices.[17] When a person finds the appropriate AT, they are able to complete tasks that they previously could not complete, did slowly, or did poorly. The right AT augments, bypasses, or compensates for a disability. This chapter will highlight the findings of the rapid literature review relative to what is presently known about AT use in educational settings.

4.1 Universal Screening: AT Child Find

A common characteristic of pediatric health care involves universal vision and hearing screenings to detect issues (a) that may impair learning and development, and (b) that are easily corrected with appropriate interventions. Similarly, local authorities often develop outreach activities to families to identify young children who may be eligible for early intervention special education preschool services.

Yet, despite global support advocating for the equitable use of AT, there is no evidence of any policy that promotes universal screening of children who may be able to benefit from AT. This means that pupils and students who use AT do so because someone championed their special needs by navigating the educational, service delivery, and funding systems in order to secure access to appropriate AT devices and services. If educational systems are truly committed to ensuring that students have access to appropriate AT devices and services, significant attention must be focused on policies and procedures associated with universal AT screening to find all children and students who are experiencing unnecessary frustration and failure in core life functions (i.e., communication, independence, education, mobility) who could benefit from AT.

[17] https://abledata.acl.gov/

4.2 Prevalence of AT Use in Education

Little is known about the prevalence of AT users within educational systems because most studies focus only on a small geographic sample (i.e., one local authority, one special school) that is not necessarily representative of the larger population. Only two large-scale studies focused on AT use in schools[18] were identified in this review but methodological shortcomings limit their value for understanding, at the population level, how many pupils and students use AT. Despite the general advocacy for AT by policymakers, educators, parents, and developers, there is no credible evidence to suggest that everyone who could benefit from AT has access to appropriate AT devices and services. As a result, there is a huge gap between the potential of AT and the reality of pupils with special educational needs and disabilities who needlessly struggle on a daily basis to complete routine tasks because they do not have ready access to appropriate AT devices and services.

To address this void, AT policy researcher Diane Golden[19] created a series of estimates to help school administrators understand the number of potential AT users they might expect to see within different disability groups within their jurisdiction (see Table 13) and to take action if their local numbers were significantly below these expectancy figures.

Golden's work should be subjected to empirical testing through new AT policy research. First, research is needed to validate the expectancy figures through surveys of AT consumers and experts to determine if indeed the ranges are accurate and reasonable concerning the need for AT. Second, research is needed to determine the prevalence of AT use within each disability category of the school and college population. Empirically validating the difference between expectancy and prevalence figures will help policymakers, educators, and practitioners establish priorities for AT service delivery systems.

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[18] Bausch, M. E., Ault, M. J., & Hasselbring, T. S. (2015). Assistive technology in schools: Lessons learned from the National Assistive Technology Research Institute. In D.L. Edyburn, (Ed.), *Advances in special education technology - Volume 1: Efficacy of assistive technology interventions*, (pp. 13-50). Bingley, United Kingdom: Emerald Group Publishing. Quinn, B.S., Behrmann, M., Mastropieri, M, Bausch, M.E., Ault, J. & Chung, Y. (2009). Who is using assistive technology in schools? *Journal of Special Education Technology, 24*(1), 1-13. Fennema-Jansen, S., Edyburn, D. L., Smith, R. O., Wilson, S., & Binion, M. (2007). Developing a statewide system for providing and assessing outcomes of assistive technology. *Journal of Special Education Technology, 22*(1), 37-52.

[19] Golden, D. (1999). Assistive technology policy and practice. What is the right think to do? What is the reasonable thing to do? What is required and must be done? S*pecial Education Technology Practice, 1*(1), 12-14.

Table 13 Golden's AT Expectancy Figures	
Disability	% Expected Use of AT
Deaf and hard of hearing	100%
Blind and visually impaired	100%
Physical disability	100%
Deaf/blind	100%
Multiple disabilities	100%
Traumatic brain injury	50-75%
Autism	50-75%
Learning disability	25-35%
Health impairment	25-35%
Cognitive disability	25-35%
Speech/language-disorder	10-25%*
Emotional disability	10-25%
*Note: Most students who need and/or use augmentative communication devices have an identified disability other than speech/language, thus the lower projected usage for this diagnostic category.	

4.3 What Types of AT Help Which Kinds of Disabilities?

One method for understanding the application of AT is to examine functional domains. The International Classification of Functioning Disability and Health (ICF)[20] is a recognised taxonomy for coding factors that reflect a person's health rather than focusing on one's disease, illness, or disability. The strength of the ICF is that it standardises the vocabulary and classification of human functioning. However, one criticism of the ICF is that it promotes a medical model of disability and therefore is insufficiently sensitive for informing the design, delivery, and evaluation of pedagogical interventions focused on learning and development (e.g. cognition, executive functioning, memory, problem solving). A children and youth version of the ICF (ICF-CY)[21] was released in 2007. In the current study, 26 documents made reference to the ICF. However, researchers have noted fundamental limitations of the ICF model for measuring AT interventions and outcomes.[22]

[20] World Health Organization. (2001). International Classification of Functioning, Disability and Health. Geneva, Switzerland: Author. https://www.who.int/classifications/icf/en/

[21] International Classification of Functioning, Disability and Health: Children and Youth Version: ICF-CY. https://apps.who.int/iris/handle/10665/43737

[22] Smith, R.O., Jansen, C., Seitz, J., & Rust, K.L. (n.d.). ATOMS project technical report: The ICF in the context of assistive technology (AT) interventions and outcomes. Retrieved from http://www.r2d2.uwm.edu/atoms/archive/icf.html

For the purpose of this study, seven domains were used to code the application of AT found in the rapid literature review: access, behavioral/social, communication, employment, independence, learning/cognition, and mobility. Table 14 summarises the number of found documents within each of the domains. Low numbers in the area of behavioral/social are not surprising given the limited work in this area. Similarly, the low numbers found in employment and mobility were expected as an artifact of the inclusion/exclusion criteria.

Table 14 Number of Documents by Domain

Domain	*Number of Found Documents*	*Percentage of the Total Corpus*
access	396	29.4%
behavioral/social	9	0.5%
communication	250	18.5%
employment	12	1%
independence	97	7.2%
learning/cognition	544	40.4%
mobility	40	3.0%
Total (exceeds 968 articles)	1,348	100%

Whereas the impact of a disability can be manifest in many ways for any given individual, there are general domains impacted within a disability category. Table 15 summarises the relevance of the six domains for each disability category. Readers interested in a specific disability category are encouraged to focus on a particular row to understand the relevant applications of AT. Readers interested in a specific domain of AT are encouraged to explore the table columns to understand the various groups that may benefit.

Table 15 Relevant Domains of Potential AT Application by Disability						
	Domains					
Disability	access	behavior/social	communication	independence	learning	mobility
autism spectrum disorder	•	•	•	•	•	
deafness	•		•	•	•	•
deaf-blindness	•		•	•	•	•
emotional and behavioral disorders		•			•	
hearing impairment	•			•	•	
intellectual disability	•	•	•	•	•	•
orthopedic impairments	•			•	•	•
specific learning disability	•			•	•	
speech language or communication	•	•	•	•	•	•
traumatic brain injury	•		•	•	•	•
visual impairment	•		•	•	•	•

Readers interested in detailed listings of types of AT by domain and disability are encouraged to consult the online technical report (www.knowledge-by-design.com/ukat/).

4.4 What is Known about AT Use by Pupils and Students with Autism?

Autism Spectrum Disorder (ASD) is a developmental disability that affects an individual's ability to communicate and engage in social interaction. For reasons unknown, the incidence of autism is increasing and is estimated to affect 1 in 54 children.[23] 31% of children with autism also have an intellectual disability (i.e. IQ < 70). Access, behavior/social, communication, independence, and learning, are relevant domains for assistive technology applications. Relevant types of AT for this population include picture-supported text, visual schedules, social skills training, video modeling and prompting, communication boards, and augmentative and alternative communication (AAC). In this review, 77 documents were identified pertaining to AT use by pupils and students with autism and the evidence levels were as follows: 42 demonstrates a rationale, 28 emerging, and 11 moderate-strong.

4.5 What is Known about AT Use by Pupils and Students Who are Blind and Deaf?

The comorbid impact of blindness and deafness makes this one of the most isolating and challenging disabilities. Deaf-blindness is a low incidence disability impacting less than 1% of the population.[24] Access, communication, learning, mobility, and independence are critical domains for assistive technology applications. Relevant types of AT for this population include braille, sign language, tactile graphics, wayfinding, mobile technologies, accessible computer workstations, and alternative access devices. In this review, 10 documents were identified pertaining to AT use by pupils and students with deaf-blindness and the evidence levels were as follows: 5 demonstrates a rationale, and 5 emerging. Additional research and development in this area is sorely needed.

4.6 What is Known about AT Use by Pupils and Students with Hearing Impairments?

Hearing loss is a sensory disability that impacts an individual's ability to process oral information. Hearing impairments are classified as slight, mild, moderate, severe, or profound and generally affect everyone as a function of aging. Access, independence, and learning, are relevant domains for assistive technology applications. Relevant types of AT for this population include assistive listening devices, personal amplification systems, hearing aids, speech to text, signaling devices, and sign language. Cochlear implants are also a potential medical technology intervention but was considered out of

[23] https://www.autismspeaks.org/autism-statistics
[24] https://www.nationaldb.org/info-center/overview-factsheet/

scope for this review. In this review, 27 documents were identified pertaining to AT use by pupils and students with hearing impairments and the evidence levels were as follows:11 demonstrates a rationale, and 16 emerging.

4.7 What is Known about AT Use by Pupils and Students with Emotional/Behavioral Disturbance?

Pupils and students with emotional/behavioral challenges may exhibit aggression towards others, refuse to co-operate, distractibility and impulsiveness, impaired social interactions, and other mental heath issues such as anxiety, low self-esteem, negative self-concept, or withdrawal. Behavior/social and learning are relevant domains for assistive technology applications for this population. Relevant types of AT for this population include video modeling and prompting, social skills training, self-monitoring data systems, and augmentative and virtual reality. In this review, 9 documents were identified pertaining to AT use by pupils and students with emotional/behavioral challenges and the evidence levels were as follows: 6 demonstrates a rationale, and 3 emerging.

4.8 What is Known about AT Use by Pupils and Students with Intellectual Disabilities?

Intellectual disabilities (ID), historically referred to as mental retardation, are a developmental disability that can affect an individual's intelligence and adaptive behavior and may be classified as mild, moderate, severe, or profound. Intellectual disabilities may be concurrent with other impairments that impact communication or mobility. Access, behavior/social, communication, independence, learning, and mobility are all relevant domains for assistive technology applications. Relevant types of AT for this population include picture-supported text, visual schedules, social skills training, video modeling and prompting, communication boards, and augmentative and alternative communication (AAC), audio books, alternative access, wearable AT, wayfinding, and more. In this review, 71 documents were identified pertaining to AT use by pupils and students with ID and the evidence levels were as follows: 27 demonstrates a rationale, 40 emerging, and 4 moderate-strong.

4.9 What is Known about AT Use by Pupils and Students with Physical Disabilities?

Physical disabilities, also known as orthopedic impairments, are those that affect an individual's motor abilities. Examples include cerebral palsy, spinal cord injury, multiple sclerosis, spina bifida, or amputation. These conditions can exist in isolation or comorbid

with other disabilities. Access, independence, learning, and mobility are relevant domains for assistive technology applications. Relevant types of AT for this population include alternative methods for accessing the computer keyboard and mouse such as switches and eye-gaze, speech to text, wheelchairs, wearable AT, and writing aids. In this review, 85 documents were identified pertaining to AT use by pupils and students with physical disabilities and the evidence levels were as follows: 37 demonstrates a rationale, 46 emerging, and 2 moderate-strong.

4.10 What is Known about AT Use by Pupils and Students with Specific Learning Disabilities?

Specific learning disabilities (SLD) are high incidence disabilities that can affect an individual's ability to read, write, and/or calculate. In the UK, it is estimated that 1.5 million people have a learning disability.[25] However, one problem associated with obtaining special educational services and AT for this population is that SLD are considered hidden disabilities. That is, they are not readily discernable. Access, independence, and learning are relevant domains for assistive technology applications. Relevant types of AT for this population include audio books, text to speech, speech to text, talking calculators, text simplification, spelling and grammar checkers, graphic organizers, writing aids, and more. In this review, 81 documents were identified pertaining to AT use by pupils and students with SLD and the evidence levels were as follows: 45 demonstrates a rationale, 33 emerging, and 3 moderate-strong.

The Need for Technology

The silence of speechlessness is never golden. – Bob Williams,[26] AAC user

4.11 What is Known about AT Use by Pupils and Students with Speech, Language, and Communication Needs?

The area of speech, language, and communication needs is the most studied area of assistive technology. These types of impairments may affect one or more aspects of communication, such as production of speech sounds, stammering, voice problems, making sense of language, problems using language, or difficulty interacting with others.

[25] https://www.mentalhealth.org.uk/learning-disabilities/help-information/learning-disability-statistics-

[26] Williams, B. (2000). More than an exception to the rule. In M. Fried-Oken & H. Bersani (Eds.), *Speaking up and spelling it out* (pp. 245–254). Baltimore, MD: Paul H. Brookes.

The prevalence of these issues is considered a high incidence disability. Access, behavioral/social, communication, independence, and learning, are relevant domains for assistive technology applications. Relevant types of AT for this population include picture-supported text, communication boards, augmentative and alternative communication (AAC), instructional software/apps, mobile technologies, and wearable AT. In this review, 125 documents were identified pertaining to AT use by pupils and students with speech, language, and communication needs and the evidence levels were as follows: 72 demonstrates a rationale, 45 emerging, and 8 moderate-strong.

4.12 What is Known about AT Use by Pupils and Students with Traumatic Brain Injury?

A traumatic brain injury (TMI) could be congenital or acquired. Depending on the area of the brain affected it may impact an individual's communication, mobility, and/or cognition. Access, communication, independence, learning and mobility are relevant domains for assistive technology applications. Relevant types of AT for this population include alternative methods for accessing the computer keyboard and mouse, memory aids, speech to text, audio books, computational tools, and writing aids. In this review, 17 documents were identified pertaining to AT use by pupils and students with TMI and the evidence levels were as follows: 7 demonstrates a rationale, 7 emerging, and 4 moderate-strong.

4.13 What is Known about AT Use by Pupils and Students with Visual Impairments?

Visual impairments are a sensory disability that affects an individual's ability to perceive information and may be classified as mild, moderate, severe, or blind. Whereas everyone loses visual acuity as they age, most mild visual impairments are remedied through the prescription of eyeglasses. Access, communication, independence, learning and mobility, are relevant domains for assistive technology applications. Relevant types of AT for this population include magnification, screen readers, text to speech, tactile graphics, wayfinding, mobile technologies, accessible computer workstations, and alternative access devices. In this review, 93 documents were identified pertaining to AT use by pupils and students with visual impairments and the evidence levels were as follows: 40 demonstrates a rationale, 52 emerging, and 1 strong (i.e. Cochrane Review).

4.14 Are There Differences in AT Use Across Grade Levels?

To-date, little is known about differences in assistive technology use across grade levels. To answer this research question, the documents were coded by the level of the AT users targeted for the intervention. Excluded from the following summary are studies that

included multiple levels and documents that spoke to pupils and students at all educational levels. The results suggest a slight increase in AT as pupils and students become older (see Table 16). However, the findings are difficult to interpret for two reasons. First, there are no baseline population studies to inform our understanding of the prevalence of AT users across the levels of the educational system, Second, there is no systemic way to assess the bias against providing AT interventions because of the myth that AT will undermine motivation to learn how to perform the target behavior.[27]

Table 16 AT Use by Grade Level

Level, Age, Grade	*Number of Found Documents*	*Percentage of the Total Corpus*
early learning (ages 2-6 or pre-K/ K)	41	15.7%
elementary (ages 7-11 or grades 1-6)	47	18%
middle/secondary (ages 12-17 or grades 7-12)	70	26.8%
further education (ages 18+ or grade 13 and beyond)	103	39.5%
Total	261	100%

4.15 Conclusions: AT Use in Educational Settings

An early observer of the special education technology knowledge base, Hannaford[28] offered the following cautionary tale: “Much of what is presented as being known about the use of computers with exceptional persons is actually what is believed, felt, or hoped. While there is an increasing amount of research and evaluation support associated with various uses of technology, there is still relatively little empirical support for many statements found in the popular literature” (p. 12).

[27] Murphy, P. (2010). Common AAC myths-sorting reality from untruth. *Closing the Gap, 29*(1), 12-14. Redford, K. (2019). Assistive technology: Promises fulfilled: From a teacher’s perspective, assistive technology delivers on its potential to transform learning experiences for students with—and without—learning disabilities. *Educational Leadership, 76*(5), 70-74.

[28] Hannaford, A.E. 1993). Computers and exceptional individuals. In J.D. Lindsey (Ed.), *Computers and exceptional individuals* (pp. 3-26). Austin, TX: Pro-Ed.

Twenty-seven years later we have (a) far more knowledge about AT devices and services, and (b) evidence about how specific forms of assistive technologies improve outcomes for specific types of students with exceptional needs and disabilities. Yet, there is much more to uncover. As Hattie[29] argues, the research evidence base, while not definitive in all cases, offers significant guidance for improving educational practice that has yet to be implemented at scale.

As this chapter has demonstrated, assistive technologies have important applications for all individuals who struggle with routine tasks. As a result, there is an urgent need to provide professionals with guidance about who might immediately benefit from AT and what could be achieved, given the right conditions. A topic we turn our attention to in the next chapter.

[29] Hattie, J. A. (2009). *Visible learning: A synthesis of over 800 meta-analyses relating to achievement*. New York, NY: Routledge.

5.0 What is Most Effective When it Comes to AT Implementation and Use?

The design, marketing, and use of AT must be understood in the context of technology used in education (i.e. educational technology) as well as technology used in society (i.e., mainstream technology; see Figure 1). Since the late 1990s and the development of a paradigm known as *universal design for learning*, designers have sought to understand the specialised needs of individuals with disabilities in order to design products that are "usable by the widest range of people operating in the widest range of situations as is commercially practical."[30]

This context is important to understand since increasingly AT is not always a separate specialised product only used by people with disabilities (e.g. smartphone, tablet). For example, graphic organisers may be introduced to all pupils and students in the context of teaching writing strategies and therefore may be considered an educational technology. Whereas many students will abandon this software after they have internalised the prewriting strategies they have learned from the graphic organiser, some students with a disability will require on-going use of these tools as AT because they are unable to complete the task without it. This chapter will highlight issues from the rapid review of the literature concerning what is known about effective AT implementation.

5.1 System Level Variables Impacting Efficacy

The equitable implementation of technology in education requires an understanding of system-level factors influencing how technology is acquired and used in classrooms. Based on a review of the literature, the Jefferson Education Exchange[31] summarised 12 clusters of 70 variables that have been identified in the research literature as impacting the effectiveness of educational technologies in education (see Figure 6). This comprehensive framework has potential application in the field of AT to supplement the many individual variables have been previously identified as facilitators or barriers.[32]

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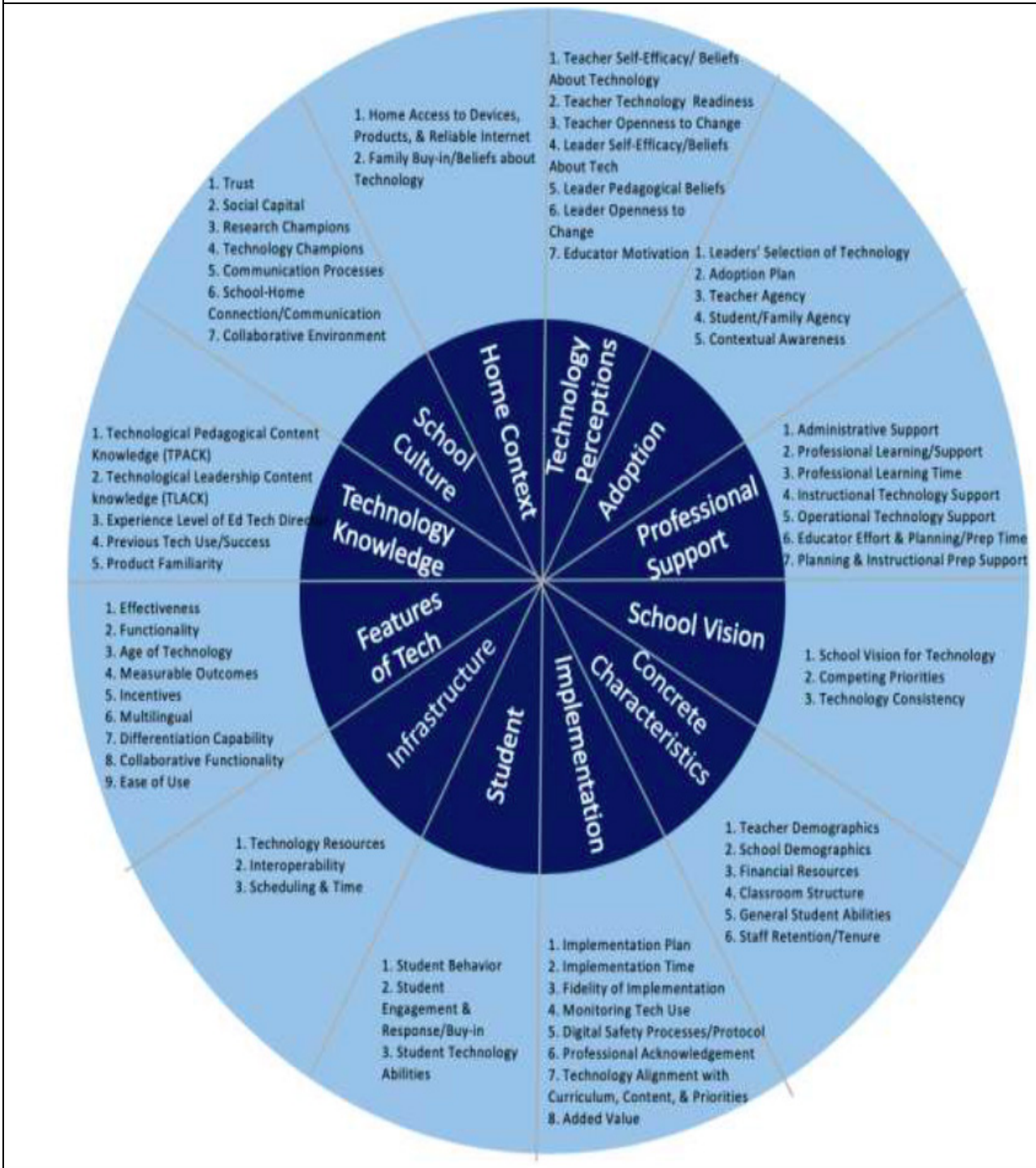
[30] Vanderheiden, G.C. (2000, November). Fundamental principles and priority setting for universal usability. In Proceedings of the 2000 conference on Universal Usability (pp. 32-37). Washington, DC: ACM. http://www.acm.org/pubs/articles/proceedings/chi/355460/p32-vanderheiden/p32-vanderheiden.pdf

[31] Jefferson Education Exchange. (2019). The EdTech Genome Project. Retrieved from https://www.slideshare.net/DanBrown143/the-edtech-genome-project-the-jefferson-education-exchange-170986887

[32] Boot, F. H., Owuor, J., Dinsmore, J., & MacLachlan, M. (2018). Access to assistive technology for people with intellectual disabilities: A systematic review to identify barriers and facilitators. *Journal of Intellectual Disability Research, 62*(10), 900-921.

Figure 3
70 Variables Identified as Influencing the Effectiveness of Educational Technology



To-date, no studies have been identified that examine the compatibility and/or friction between educational technology (ET) and assistive technology (AT) service delivery systems within education establishments that are typically siloed as different administrative and service delivery units.[33] Yet, strong leadership has offered vision and guidance when professional organisations[34] and educational agencies[35] take the lead in articulating the benefits associated with universal accessibility within educational systems.

5.2 What is Known about the Efficacy of Various AT Service Delivery Models?

Without a system of universal screening for AT (see section 4.1), AT devices and services are primarily provided in a reactive fashion. That is, someone within the educational system must advocate for a struggling pupil or student by making a referral for an AT assessment. Based on those findings, recommendations may or may not be made to provide AT. This state of practice is revealed in vastly different AT prevalence figures from many different localities and contributes to inequitable access and use of AT.

Educational systems may manage their AT personnel and services through one of three primary service delivery models. For example, in some jurisdictions, AT is a component of special education services. This historical approach tends to silo AT and often produces friction between AT and educational technology (ET) personnel as they debate the merits of standardised technology tools provided to all staff and students and specialised tools that may be needed by only a single student. In this model, budget, personnel, and training are all siloed in either special education or general education with very little collaboration between the units.

A second model occurs in situations where the status of AT has been elevated by school and college leadership who set priorities for inclusive education or multi-tier support systems (MTSS) where the general education classroom is viewed as the home unit for

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[33] Negrea, S. (2019). Tech-ommodations: Digital-age disability services: Models for managing assistive technology through partnerships between disability services and IT. *University Business*, November/December, 39-41.

[34] Fletcher, G., Levin, G., Lipper, K., & Leichty, R. (2014). *The accessibility of learning content for all students, including students with disabilities, must be addressed in the shift to digital instructional materials. SETDA policy brie*f. Glen Burnie, MD: State Educational Technology Directors Association.

[35] Martin, N., Wray, M., James, A., Draffan, E. A., Krupa, J., & Turner, P. (2019). *Implementing inclusive teaching and learning in UK higher education – Utilising universal design for learning (UDL) as a route to excellence*. Society for Research into Higher Education. Retrieved from https://openresearch.lsbu.ac.uk/item/8666q Maryland State Department of Education. (2011). *A route for every learner: Universal design for learning (UDL) as a framework for supporting learning and improving achievement for all learners in Maryland, prekindergarten through higher education.* Baltimore, MD: Author.

all students with a goal of making differences ordinary. In this model, all students, for example, will learn to write. However, some students will use a standard word processor while other students may use word prediction tools to help them overcome severe spelling disabilities or speech to text tools to allow them to dictate their essay to overcome the inability to use the standard keyboard and mouse. This approach to AT devices and services often views technology as a toolkit such that the individual components can be swapped out as needed. In this model, budget, personnel, and training are all resources that are called upon to solve technology access problems with extensive collaboration to all stakeholders.

A third model represents an evolution of accessibility. It may be represented as a component of a Multi-Tiered Support System (MTSS) model or a claim of status for seeking to implement state-of-the-art universal usability. In this model, AT and ET personnel work intimately together to procure universally accessible technologies (that is, accessible out of the box: accessibility features are built-into products that just need to be turned on as needed). In this model, there is no longer a single accessible computer station in the classroom or library, but rather, all computer workstations are fully accessible and a student can use any computer. Furthermore, if a pupil or student uses specialised devices like an alternative keyboard or mouse, these devices will plug right in and work instantly. In some cases, a school, college or local authority may refer to this kind of service delivery model as *Universal Design for Learning* (UDL) but this term lacks a clear operational definition so it is impossible to discern its full implications as a service delivery system.

To-date, there are no research studies examining the efficacy of various AT service delivery systems/models. The literature features numerous studies about *user satisfaction* with AT devices and services that serve as an inadequate proxy for AT outcomes. As a result, there is a considerable need for AT research that focuses on quantitative measures of return on investment (ROI) and performance under varying conditions. Studies by Koester and Arthanat[36] offer a model for AT research that advance the profession's empirical evidence base while simultaneously providing critical data for consumer decision-making about what works rather than simply relying on user preferences.

[36] Koester, H. H., & Arthanat, S. (2018a). Text entry rate of access interfaces used by people with physical disabilities: A systematic review. *Assistive Technology, 30*(3), 151-163. Koester, H. H., & Arthanat, S. (2018b). The design, conduct, and reporting of research on text entry with alternative access interfaces: Recommendations from a systematic review. *Technology and Disability, 30*(3), 83-95.

5.3 Components Necessary for Successful AT Implementation

A number of factors are thought to be essential for the successful implementation of AT in educational settings.[37] However, the quality of these data are often at the level of expert opinion rather than empirical evaluation of alternative AT service delivery models. With that caveat, stakeholders are encouraged to consider the following components necessary to ensure successful AT implementation:

• Develop Personnel Preparation Pathways that Provide General AT Knowledge

Teachers, speech therapists, occupational therapists, and special education administrators need pre-service[38] and in-service[39] training concerning their roles and responsibilities for team-based AT decision-making in order to understand who might need AT, how to evaluate various AT interventions, and the types of AT outcomes that should be anticipated. Without this common professional knowledge in every school and college, it is unlike that societal goals for AT use will be achieved. This component is comparable to the extensive research base in education technology, that is, teachers need training in order to maximise the effectiveness of technology.

• Develop Personnel Preparation Pathways that Develop Specialised AT Knowledge

Beyond the general awareness and knowledge described above, it is essential that leadership pathways be developed for school-based and college-based personnel to develop AT expertise. AT leadership personnel often serve as the AT diagnostic leader or the AT team leader. It is common to have an AT Specialist at the jurisdiction level and desirable to have an AT Specialist within each school or college building. Without a local AT leader, it is unlikely that there will be consistency across levels, units, or programs.[40]

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[37] Karlsson, P., Johnston, C., & Barker, K. (2018). Influences on students' assistive technology use at school: The views of classroom teachers, allied health professionals, students with cerebral palsy and their parents. *Disability and Rehabilitation: Assistive Technology, 13*(8), 763-771.

[38] Bausch, M. E., & Ault, M. J. (2012). Status of assistive technology instruction in university personnel preparation programs. *Assistive Technology Outcomes and Benefits, 8*(1), 1-14. Judge, S., & Simms, K. A. (2009). Assistive technology training at the pre-service level: A national snapshot of teacher preparation programs. *Teacher Education and Special Education, 32*(1), 33-44. Medola, F. O., Sandnes, F. E., da Silva, S. R, & Rodrigues, A. C. (2018). Improving assistive technology in practice: Contributions from interdisciplinary research and development collaboration. *Assistive Technology Outcomes and Benefits, 12*(1), 1-10. Smith, E. M., Gowran, R. J., Mannan, H., Donnelly, B., Alvarez, L., Bell, D., ... & Jan, Y. K. (2018). Enabling appropriate personnel skill-mix for progressive realization of equitable access to assistive technology. *Disability and Rehabilitation: Assistive Technology, 13*(5), 445-453.

[39] Reed, P., Kaplan, M., & Bowser, G. (2009). *The assistive technology trainer's handbook*. Roseburg, OR: National Assistive Technology in Education Network.

[40] Breslin Larson, J., & Carl, D. (2019). Building sustainable leadership and practices in assistive technology. *Closing the Gap, 38*(1), 3-7. Courduff, J., Szapkiw, A., & Wendt, J. L. (2016). Grounded in what

• Establish AT Teams

Given the transdisciplinary nature of AT, teams of professionals are required to evaluate the need for AT and develop AT implementation plans. Beyond the professional development required in the previous two components, team members will need load reductions to enable them to meet, conduct AT evaluations, and support AT implementation. Without a building-level AT team, the likelihood of successful AT implementation is quite limited.[41]

• Standardise AT Evaluation Procedures and Protocols

There is little consistency between educational agencies about how they evaluate the need for AT. Whereas there are a number of AT assessment models, few have been empirically validated. Similarly, there are few standardised AT assessment instruments or protocols. Best practice indicates that students should experience multiple AT devices in order to collect data about which intervention might be most effective.[42] There is an urgent need to standardise the AT evaluation process in order to ensure the equitable distribution of AT to all pupils and students who could benefit and move beyond the distribution in the hope that it will help because “nothing else to-date has shown benefit.”

works: Exemplary practice in special education teachers’ technology integration. *Journal of Special Education Technology, 31*(1), 26-38.

[41] Desideri, L., Ioele, F. M., Roentgen, U., Gelderblom, G. J., & de Witte, L. (2014). Development of a team-based method for assuring the quality of assistive technology documentation. *Assistive Technology, 26*(4), 175-183. Lamontagne, M. E., Routhier, F., & Auger, C. (2013). Team consensus concerning important outcomes for augmentative and alternative communication assistive technologies: A pilot study. *Augmentative and Alternative Communication, 29*(2), 182-189.

[42] Corradi, F., Scherer, M. J., & Presti, A. L. (2012). Measuring the assistive technology match. In M. Scherer, & S. Federici, (Eds.). *Assistive technology assessment handbook* (pp. 49-65). Boca Raton, FL: CRC Press. Desideri, L., Roentgen, U., Hoogerwerf, E. J., & de Witte, L. (2013). Recommending assistive technology (AT) for children with multiple disabilities: A systematic review and qualitative synthesis of models and instruments for AT professionals. *Technology and Disability, 25*(1), 3-13. Silverman, M. K., & Smith, R. O. (2006). Consequential validity of an assistive technology supplement for the School Function Assessment. *Assistive Technology, 18*(2), 155-165.

• Connect AT Devices, AT Services, with AT Outcomes

AT devices by themselves are generally insufficient to promote the functional outcomes desired.[43] As a result, significant attention must also be provided to ensuring appropriate AT services are instituted. Increased attention must be devoted to measuring the outcomes and benefits of AT use to expand the AT evidence base.

The Need for Accessible Educational Materials (AEM)

While, historically, classroom materials have come in a "one size fits all" form and method of delivery, digital content can be adjusted in real time to meet diverse student needs. In order to harness this potential, however, digital material must be the result of purposeful design and planning that takes into account considerations of accessibility at the outset. State and district policies regarding digital content, including on OER [Open Educational Resources], can help facilitate this. – Fletcher et al. (2014)[44]

5.4 How Does the Availability, or Lack Thereof, of Accessible Educational Materials (AEM) Influence the Use of AT and Impact Academic Outcomes?

The ability to access and use AT is essential, but not sufficient, for closing the achievement gap experienced by pupils and students with special educational needs and disabilities. This insight has prompted considerable attention to the nature of inaccessible curricula. Historically, the problem was a textbook[45] with its rigid fixed format. The evolution of digital education materials, as well as the wealth of information available via the World Wide Web, has helped educators appreciate the value and flexibility of digital

[43] Hoogerwerf, E., Solander-Gross, A., Mavrou, K., Traina, I, & Hersch, M. (2017). A self-assessment framework for inclusive schools supporting assistive technology users. *Studies in Health Technology and Informatics, 242*, 820-827. Layton, N., Hubbard, W., Burton, J., & Kuna, A. (2016). Quality, choice and outcomes in assistive technology (AT) equipment funding schemes: A procurement case study. *Health Systems and Policy Research, 3*(1), 1-8. Lenker, J. A., Koester, H. H., & Smith, R. O. (2019). Toward a national system of assistive technology outcomes measurement. *Assistive Technology*, 1-8. https://doi.org/10.1080/10400435.2019.1567620 Satterfield, B. (2016). History of assistive technology outcomes in education. *Assistive Technology Outcomes and Benefits, 10*(1), 1-18.

[44] Fletcher, G., Levin, G., Lipper, K., & Leichty, R. (2014). *The accessibility of learning content for all students, including students with disabilities, must be addressed in the shift to digital instructional materials. SETDA policy brief*. Glen Burnie, MD: State Educational Technology Directors Association.

[45] Wiazowski, J. (2010). (In)accessible digital textbooks. *Closing the Gap, 29*(3), 17-22.

text (e.g., change the font, size, copy, paste, summarise, convert from text to speech) for diverse range of pupils and students.[46]

In this study, 49 documents addressing AEM were identified and the evidence levels were as follows: 33 demonstrates a rationale, and 16 emerging. While there is much advocacy about the need for accessible educational materials (i.e., digital curriculum, online teaching environments), little attention has focused on the relationship between AEM and AT, and empirical work in this area is quite limited. Nonetheless, advocacy for AEM is a necessary component of AT devices and service systems. The importance of accessible educational materials cannot be underestimated during the COVID-19 pandemic and the shift to online instruction where pupils and students with special needs and disabilities may experience (1) barriers in online learning management systems (LMS), (2) multimedia and web pages that are not accessible, and/or documents that are not accessible, and (3) not having appropriate AT to support guided and independent engagement in educational activities.

5.5 Mapping a Path Forward

AT is an under-utilised intervention to provide pupils and students with special needs and disabilities a means for accessing and engaging in the curriculum in ways that are representative of the ubiquitous nature of technology in society. Realising the potential of assistive technology will required the coordinated efforts of students, parents, educators, administrators, policymakers, developers, service providers, and researchers to examine policy, products, personnel, and provision systems.[47] Tactics known as *Frugal Innovation*[48] may be particularly helpful during and after the COVID-19 pandemic that has caused significant budget contractions.

However, let us be mindful that advances in *universal usability* have provided access tools on every smartphone, computer tablet, laptop, and desktop computer. Parents and educators are encouraged to explore the accessibility features on their devices as a critical first step in locating appropriate AT. The development and expansion of formal AT

[46] McLaren, R. (2018). Accessible virtual learning environments: Making the most of the new regulations. Retrieved from https://www.policyconnect.org.uk/research/accessible-virtual-learning-environments-making-most-new-regulations

[47] Desmond, D., Layton, N., Bentley, J., Boot, F. H., Borg, J., Dhungana, B. M., ... & Mavrou, K. (2018). Assistive technology and people: A position paper from the first global research, innovation and education on assistive technology (GREAT) summit. *Disability and Rehabilitation: Assistive Technology, 13*(5), 437-444. Durocher, E., Wang, R. H., Bickenbach, J., Schreiber, D., & Wilson, M. G. (2019). “Just access”? Questions of equity in access and funding for assistive technology. *Ethics & Behavior, 29*(3), 172-191.

[48] Cadeddu, S. B., Layton, N., Banes, D., & Cadeddu, S. (2019). Frugal innovation and what it offers the assistive technology sector. In N. Layton, & J. Borg, (Eds.), *Global perspectives on assistive technology: Proceedings of the GReAT Consultation 2019, Volume 2* (pp. 487-502). Geneva, Switzerland: World Health Organization.

assessment procedures and systems in every school and college jurisdiction will be an essential step in identifying pupils and students in need of AT.[49] The establishment of AT Seedbeds[50] will be an important investment to assist developers, educators, administrators, policymakers, and researchers in understanding what types of AT devices and services help which types of students. Additional attention to the pre-service and in-service teacher professional development is a critical need since the lack of awareness about AT is a major obstacle for students to receive appropriate AT devices and services. Finally, there is an urgent need for on-going data collection about AT use and research on measuring AT outcomes.

The Need for Technology

…disability is a rich and indispensable site and "test bed" for how societies can confront technology for better futures. – Goggin, Ellis, & Hawkins (2019), p. 298.

[49] Hemphill, C., Layton, N., Banes, D., Long, S., & Hemphill, C. (2019). Evaluating the economics of assistive technology provision. In N. Layton, & J. Borg, (Eds.), *Global perspectives on assistive technology: Proceedings of the GReAT Consultation 2019, Volume 1* (pp. 248-268). Geneva, Switzerland: World Health Organization.

[50] Goggin, G., Ellis, K., & Hawkins, W. (2019). Disability at the centre of digital inclusion: Assessing a new moment in technology and rights. *Communication Research and Practice, 5*(3), 290-303.

Reference: DFERPPU/2019/038

ISBN: 978-1-941171-02-8

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