☑ CEU Article

# The Impact of Assistive Technology on the Educational Performance of Students with Visual Impairments: A Synthesis of the Research

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***Abstract:*** This synthesis examined the research literature from 1965 to 2009 on the assistive technology that is used by individuals with visual impairments. The authors located and reviewed 256 articles for evidence-based research on assistive technology that had a positive impact on educational performance. Of the 256 studies, only 2 provided promising evidence-based practices.

For centuries, technology has been harnessed to provide opportunities to individuals with visual impairments (that is, those who are blind or have low vision). The use of such assistive devices can be traced back to the use of a cane, stick, staff, or bamboo pole found in the writings of the ancient Hebrews, Greeks, and Chinese (James & Thorpe, 1994; Neustadt-Noy & LaGrow, 1997). Today, more advanced tools (assistive technology) are used by individuals with visual impairments to access information, travel independently, and participate in a variety of activities (Lowenfield, 1973). In essence, assistive technology has the potential to be the "great equalizer" for individuals with disabilities (Michaels & McDermott, 2003). It can be used to address many of the challenges that individuals with visual impairments face.



The ability to access information is essential for success in education, employment, and life (Kapperman & Sticken, 2000; Scadden, 2000). Therefore, much of the development of assistive technology for individuals with visual impairments has focused on providing access. For example, tools such as the slate and stylus used to create braille were the first assistive technology devices that allowed people with visual impairments to be truly literate after the creation of the braille code in the 1800s (Hatlen, 2000; Scadden, 2000). Braille was first written using a slate and stylus, a handheld device by which a person makes braille symbols by embossing paper with a sharp tool. Manual braillewriters were developed in the late 19th century; this tool increased the speed and quantity of braille production. In the early 1900s, audio technology

 

*Table 1*
**Operational definitions of key terms in relation to the use of assistive technology.**

| Key term | Definition |
|---|---|
| Effective | Having a positive impact on education |
| Effectiveness | The degree to which assistive technology (the independent variable) has a positive impact on educational performance (the dependent variable) |
| Evidence-based research | The use of scientific research to establish best practices determined by an evaluation of the research |
| Scientifically based research | A research design that determines with the highest degree of probability whether an intervention was the factor that caused the effects |

(radios, records, and recorders) provided more access to information than did braille, because of the development of the technology for the mass market (Scadden, 2000).

The development of the computer in the 1960s led to an explosion of technologies that individuals with visual impairments could use to access information. Braille embossers (a specialized tactile printer), advanced closed-circuit televisions (CCTVs: devices that enlarge written or printed text), scanners and optical character recognition software (technology that scans printed text and provides the user with speech output), computer screen readers, compact discs (CDs), and multiple hardware and software innovations have enhanced the ability of individuals with visual impairments to access information (Kapperman & Sticken, 2000).

It is generally accepted that assistive technology has a positive impact on the lives of individuals with visual impairments (Cooper & Nichols, 2007; Kapperman, Sticken, & Heinze, 2002; Strobel, Fossa, Arthanat, & Brace, 2006). However, most of the assistive technology devices that are used by individuals with visual impairments are deemed effective (see Table 1 for the operational definition of the term) merely because they have practical application. For example, the manual braillewriter is considered effective (or as having had a positive impact on education) because it has provided individuals with visual impairments with access to information (through the ability to write braille) faster than the slate and stylus. It may be true that the manual brailler is faster than the slate and stylus because of the obvious inherent characteristics of the two assistive devices. However, this sort of anecdotal evidence is not sufficient for other types of assistive technology (for example, two screen-reading software applications compared with each other or two electronic note-taking devices compared with each other). The comparison of the effectiveness of assistive technology (see Table 1 for the operational definition of the term) is considerably more complex.

Assistive technology tends to be developed faster than researchers can evaluate it. Despite the speed of production, such technology is not guaranteed to be effective. Professionals in the field must strive to evaluate its effectiveness in an effort to provide consumers with the information that will allow them to have the highest-quality experience possible when using

 

such techology. In this era of accountability, professionals need to demonstrate effectiveness, regardless of any extenuating circumstances related to the rapid advancement of products. With all this in mind, we investigated two broad questions in the study presented here: What is the knowledge base regarding assistive technology and the education of individuals with visual impairments? and To what extent has the field determined, through rigorous, scientific-based methods, the effectiveness of assistive technology for individuals with visual impairments?

## Method

In the study, we defined the term *assistive technology* as it has been defined by the Individuals with Disabilities Education Improvement Act (IDEIA, P.L. 108-446) of 2004. According to the law, an assistive technology device is "any item, piece of equipment, or product system, whether acquired commercially off the shelf, modified, or customized, that is used to increase, maintain, or improve functional capabilities of individuals with disabilities" (IDEIA, 2004, Sec. 602, 20 USC 1401, § 300.5). The law further defines an *assistive technology service* as "any service that directly assists an individual with a disability in the selection, acquisition, or use of an assistive technology device" (§ 300.6).

With the passage of the No Child Left Behind Act of 2001 (NCLB, 2001, 20 USC § 6301 et seq.) and the IDEIA of 2004, Congress put a priority on the use of evidence-based (see Table 1 for the operational definition of the term) strategies when determining services required by and devices approved for students with disabilities. Embodied in the concept of an evidence base that drives decisions is the idea that the selection and use of technology, including assistive technology, should be rooted in research on its effectiveness. With this point in mind, we attempted to determine if the field of special education for students with visual impairments has developed any practices that have been determined to be effective (that is, evidence-based practices) by rigorous scientific research (see Table 1).

For the purposes of our study, therefore, the concept of effectiveness was scrutinized as it pertained to having a positive academic impact. We defined *assistive technology research* as such studies that examined the uses of assistive technology for classroom-based educational interventions. This criterion excluded orientation and mobility travel devices and independent living devices (equipment that is used to accomplish household-oriented tasks for daily living).

To begin to develop a body of evidence-based research that has determined the knowledge base and demonstrated the effectiveness of assistive technologies used by individuals with visual impairments, we conducted a synthesis of research on assistive technology in the field of visual impairment from January 1965 through August 2009. We used multiple means to complete the synthesis, locating articles published during this time span of 45 years that addressed research on assistive technology that was used for educational interventions with students who are visually impaired. We initially located such research by searching four electronic databases—EBSCO Academic Search Premier, EBSCO Professional Development Collection, ERIC, and PsychInfo—for references to assistive

 

technology, blindness, and visual impairment for students with and without additional disabilities. We used the Boolean search method with the "and" search operator to retrieve articles that used both specified search terms. The specific search terms that were used in each of the four databases were *blind, deaf blind, deafblind, deaf-blind, eye disorders, partially sighted, vision disorders, visual disabilities, blindness, visual impairment, visually impaired, partial vision,* and *large print,* each paired with the terms *assistive technology, instructional technology, assistive device, communication devices, accessibility, technology, computers, electronic aids, optical aids, notetaker,* and *low vision aids.*

In addition to the search of the electronic databases, we conducted a manual search of articles related to assistive technology and students who are blind or have low vision with and without additional disabilities in the *Journal of Visual Impairment & Blindness* (entitled *New Outlook for the Blind* prior to 1977) and *RE: view*. Last, we searched the reference lists of all articles we found and located other relevant articles. The search used exhaustive means to locate the research included in the study presented here.

The research we analyzed was required to meet the following general criteria to be included in the study. The research needed to (1) address the assistive technology that was used for classroom-based educational interventions, (2) include as participants in the study students with or without additional disabilities aged 3–21 in preschool through 12th-grade educational programs who were blind or had low vision, and (3) have been published between January 1965 and August 2009 in English-language refereed journals. From these criteria, we were able to establish the knowledge base regarding assistive technology and education of individuals with visual impairments.

Ancillary to the synthesis of the research, we conducted a more rigorous analysis of all the articles we identified to determine the extent of research on the effectiveness of assistive technology. The articles that met the general criteria were further examined for the presence of the results of an intervention that were intended to have an impact on the lives of children who are visually impaired with or without additional disabilities. To do so, we reviewed each study for a control or comparison group and an intervention with an experimental research design. Following the theoretical framework of Warren's (1994) individual differences approach, we determined that the comparison group could not include sighted students because the comparison would not be fair or appropriate with such students being compared to those with visual impairments. Whenever a study replicated another study, this characteristic of the article was also noted favorably.

## Results

The articles identified by this analysis covered 45 years of research pertaining to assistive technology used for classroom-based educational interventions by students who are visually impaired with or without additional disabilities aged 3–21, in preschool through 12th-grade educational programs. Of the articles we located, 28 were eliminated because some of the participants who were included in a study were outside the age range for the search. In addition, 16 articles were eliminated because the research topic included

 

skill areas, such as orientation and mobility, that were beyond the scope of the academic classroom–based focus of the review, and 3 articles were eliminated because the studies were not published in refereed journals. We found that a substantial number of articles (256) that were published during the 45-year period were aligned with the general criteria that we used to identify research articles on assistive technology for this analysis.

The study characterized the research on the basis of the following nine distinct categories. The number of articles identified in each category is also noted.

1. The article discussed theories, beliefs, or practices without a research design or method ($n$ = 122; 48%).
2. The article discussed reviews or evaluations of products without a research design or method ($n$ = 34; 13%).
3. The study used a research design or method that did not include an intervention, control group, and comparison group ($n$ = 57; 22%).
4. The study included an appropriate control and comparison group, but insufficient data were presented in the article to determine the effectiveness of the intervention ($n$ = 17; 7%).
5. The study included participants (parents, patients, families, or teachers) who were not students ($n$ = 11; 4%).
6. The study used a qualitative research design (which falls outside the realm of scientifically based research) ($n$ = 6; 2%).
7. The results and conclusions of the study are subject to validity concerns (all the participants in the study received the treatment, and the resulting effects of the intervention could not be interpreted unambiguously) ($n$ = 4; 2%).
8. The study used an inappropriate sighted comparison group ($n$ = 3; 1%).
9. The study presented sufficient data to determine the effectiveness of an intervention with appropriate participants, intervention, control group, and comparison group ($n$ = 2; 1%).

More than half the 256 articles (156) that identified assistive technology that was used for classroom-based educational interventions by students who are visually impaired were discussions of theories, beliefs, or practices; product reviews; or product evaluations without research designs or methods. Despite the certainty of the worthiness and contribution of this large segment of research, no measure of the effectiveness or impact of the assistive technology on educational performance was presented in any of these articles. Specifically, 48% of the articles were discussions of a theory, belief, or practitioner-based concept, and 13% were discussions of product reviews or evaluations. The knowledge base regarding assistive technology and education of individuals with visual impairments was shown to be largely devoted to this topic area.

Of the 121 articles that discussed a theory, belief, or practice related to education-based assistive technology without a research method, a major portion included students with additional disabilities. In these articles, students with additional disabilities were represented well by at least 20% of the articles that were identified over the entire 45-year period. Moore (1982) described ways to use new educational materials that were

 

developed specifically for students with visual impairments and additional disabilities. The article included instructional techniques for low vision stimulation kits and prevocational materials. Engleman, Griffin, Griffin, & Maddox (1999) provided a guide for communication with students with deaf-blindness. The teaching practice presented in their article included a detailed discussion of assistive technology that was available for students with deaf-blindness. Keyboarding was used as part of a whole-language approach to teach functional literacy skills to students who are visually impaired with additional disabilities (Stauffer, 2008). To help students who are visually impaired enjoy the ensemble experience provided by music educators, Siligo (2005) focused on many of the practical tools and information that can make this experience possible. The tools and information discussed by Siligo were intended to enable music educators to fully include students who are visually impaired in the ensemble experience. Although no scientific design was presented in this article, the recommended tools will be of great help to teachers who are looking for ideas for music instruction. It must be noted that Siligo's article and many others contributed to the effective use of assistive technology without providing a measurement of the magnitude of the impact.

There were 35 articles with reviews or evaluations of products that fit within the general parameters of the search. Gutknecht (1980) reviewed fundamental skills that are needed to use the Optacon and interviewed an instructor-coordinator at a residential school for her comments about students' success with the device. A new sensory aid for children who are blind, the Canterbury Child's Aid, was reviewed along with the rationale for the design features of the device (Strelow & Boys, 1979). The more recent evaluation of the Jordy magnification device, for example, provided ratings that address the usefulness of the device in performing the activities noted in the article (Francis, 2005). The product evaluation ratings of the Jordy magnification device and other similar product evaluations that were identified by the search were based solely on the authors' own observations, interactions, and opinions of the products.

We found that 83% of all the articles that were identified by the analysis (an additional 22% beyond the 61% of the articles that were discussion based) did not include comparison groups, control groups, and interventions. Much of this research often used a case-study approach with small samples of students. Nearly all the 57 research-based studies without a control or comparison group used the case-study approach. Koenig, Layton, and Ross (1992) used a case-study approach to evaluate the relative effectiveness that six students with low vision experienced when reading in large print and when reading standard print with low vision devices, and, more recently, Rovira and Gapenne (2009) used a case-study approach with three students who were blind to evaluate a device for reading and recognizing geometric line drawings. As was the outcome with each of the other case studies that were identified by the analysis, the studies provided useful information for multidisciplinary teams to consider pertaining to the observed behaviors and learning of the students, albeit in a limited fashion without the use of

 

statistically powerful sample sizes or comparison or control groups.

Although small, a certain percentage of the articles included an inappropriate sighted comparison group (Warren, 1994). For example, Bouaziz, Russier, and Magnan (2005) evaluated the ability of sighted blindfolded children and children who were visually impaired to use raised-line drawings effectively. The study provided remarkable information on the topic. However, it was clear that the participants in the group who received the intervention were not comparable to those in the comparison group. The effectiveness of an intervention cannot be evaluated in conjunction with this contradictory feature of a study. In no instance did a study replicate another study in the 45-year period of research that we searched.

The extent to which the field has researched the effectiveness of assistive technology used by students who are visually impaired with or without additional disabilities is close to nonexistent. Less than 1% of the articles that we identified provided sufficient data to determine the effectiveness of an intervention with an appropriate control and comparison group, as well as an intervention (Koenig & Ashcroft, 1983; LaGrow, 1981). Of the two studies, LaGrow's (1981) examined the effects of a CCTV on the reading rates of six college-bound students who were visually impaired using a multiple-baseline (across subjects) single-subject research design to control for and demonstrate the effectiveness of the intervention. The study found that the reading rates of each participant increased after systematic instruction. The data that were reported (that is, the mean reading rates) made it possible to measure the effectiveness of the intervention.

The second study (Koenig & Ashcroft, 1983) investigated the effect of using an electric Perkins Brailler on the participants' writing rates and accuracy. Again, a single-subject design was used on 10 participants, each of whom served as his or her own control. At the onset of the study, none of the students had used the electric Perkins Brailler, but all had used the regular Perkins Brailler. The study found no significant differences between writing methods with the electric and regular Perkins Braillers. The data that were reported (that is, mean scores, standard deviations, and *t*-values for the dependent variables) made it possible to measure the effectiveness of the intervention.

## Discussion

Our review determined that a substantial number of articles have been published pertaining to assistive technology used for classroom-based educational interventions for students who are visually impaired with or without additional disabilities aged 3 to 21 in preschool through 12th-grade educational programs. The field has a considerable knowledge base in an exceptionally specialized area of educational programming for students who are visually impaired. However, the extent to which the field has researched the effectiveness of assistive technology used by students who are visually impaired using rigorous, scientific-based methods is close to nonexistent.

A large percentage of the literature consists of anecdotal evidence of the impact of assistive technology without evaluating the effectiveness of assistive

 

technology. This finding applied to three-fifths of the articles we identified. Although evidence that is developed through practice is important, it does not provide the scientifically based evidence that is required by NCLB or IDEIA. For specific assistive technologies to be included in the Individualized Education Programs (IEPs) of students with visual impairments, the technology must provide apparent benefits (such as a brailler that provides access to information) or there must be scientific proof that it will have a positive impact on students' learning. Without scientific support, IEP committees will have a much more difficult time justifying the need for advanced assistive technologies for students with visual impairments.

There were 35 articles that reported evaluations or reviews of products and met the criteria for inclusion in our review. Apparently, in each instance, a scientific trial that would yield definitive information on the effectiveness of the product was not conducted.

Given the reality that students who are visually impaired are not widely present in public schools, many of the research designs that we identified in this review were limited to case studies and did not provide sufficient data to determine the effectiveness of an intervention. Although it is not possible to generalize the results of this small magnitude, it is possible to replicate interventions that were found in case studies with small samples of participants in an effort to create more robust findings among several studies that evaluated the effectiveness of the same tools or interventions. In addition, it may be feasible to create a series of studies based on the case studies that uses a rigorous single-subject design method. The use of a single-subject design would eliminate the inherent difficulties of finding participants in the field of visual impairment while keeping the integrity of scientifically based research.

The field has yet to replicate a study in the area of assistive technology we examined. Considerable confidence, reliability, and validity are added if an intervention is evaluated by multiple studies (Schafer, 2001). The use of replication can be especially practical for those who work in field environments, such as this area of special education, with limited options for research paradigms.

Although it is true that because the number of students with visual impairments is small, it is difficult to design experimental studies with a sufficient number of participants, it is still important and possible to implement evidence-based research. The two articles we found that provided sufficient data to determine the effectiveness of the interventions with appropriate control and comparison groups and interventions had smaller sample sizes. Single-subject research methodology was used to achieve this outcome. The measure of strength of the relationship between the assistive technology intervention and students' educational performance was measured and presented in both articles (Koenig & Ashcroft, 1983; LaGrow, 1981). The degree to which assistive technology (the independent variable) had a positive impact on educational performance (the dependent variable) was established in each instance. An apparent link between evidence-based research methods and the ability to evaluate the effectiveness of assistive technology for this population of students has been demonstrated by an

 

exhaustive synthesis of more than four decades of the literature.

### Limitations

As with any type of research, this study had some innate limitations that must be addressed. First, it was primarily a review of the current body of literature. Its only purpose was to provide information on the current state of understanding. However, it is foundational to all future endeavors in researching this area to have a well-developed understanding of the current body of research.

Second, the criteria that we established produced specific limitations. The application of scientific methodology in education is relatively new and may be a limitation in the evaluation of research that was conducted more than 10 years ago. However, it must be noted that we examined 45 years of the literature to ensure the review was exhaustive and truly representative of the literature that is available on this particular topic. To validate this undertaking further, we note that the two studies that met the criteria were conducted in the 1980s. The findings demonstrate that it was not necessary to limit the review to the most recent literature to measure the degree of scientific research available on the topic. If we had done so, the two studies that met the criteria would not have been found. Another implication of the exhaustive review of the literature covering a 45-year period and resulting in 256 articles was that it was not possible to present the entire depth of what we identified. Articles were selected that were representative of what we found, and concepts were presented in the article.

Furthermore, the review included only journals that are in English and that focused only on interventions for students aged 3–21 in preschool through the 12th grade. The review did not include dissertations or theses because we wanted to focus on the published research that is readily available to the field. However, it must be stated that excellent scientifically based research may be found in nonpeer-reviewed dissertations. The removal of any of these criteria from other reviews may yield more research that is scientifically rigorous.

## Conclusion

The research that we identified is valid and helpful. Even though a study did not use the rigorous standards of scientifically based research, it is still of great help to teachers and other professionals who are looking for ideas and ways to advance instructional techniques. It must be strongly stated that the current body of literature enables the effective use of assistive technology.

In this era of NCLB and IDEIA regulations, more research-based evidence for the use of strategies and skills should be provided to allow for measures of the effectiveness of educational priorities. There is a great need to develop a body of scientifically based research. Scientifically based research methods seem to be indicative of the evaluation of the effectiveness of assistive technology, and vice versa. This interdependent relationship was demonstrated by our study. For students with visual impairments to be able to receive high-quality assistive technology that will enhance their educational success, more concrete research on the effectiveness of assistive technology needs to be conducted.

It is time to begin to replicate studies and to ensure that the studies follow even higher standards. As newer technologies

 

continue to emerge, the research should become increasingly more sophisticated in this topic area as well. Without a rigorous boost in research, it is difficult to be certain what the field of visual impairment needs to do to ensure instructional practices keep up with the digitalization of society in this time of technological prominence.

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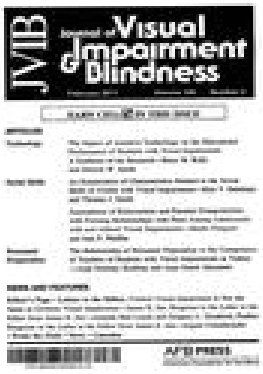


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