Improving the Nation's Capacity to Teach Children With Sensory and Severe Disabilities

NCLID

National Center on Low-Incidence Disabilities

Forty Years of Literacy Research in Blindness and Visual Impairment[1]

Technical Report[2]

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Literacy is the key to social and economic opportunity (Rex, Koenig, Wormsley, & Baker, 1994; Schroeder, 1989). This is obvious when contemplating all the ways in which literacy is weaved into the daily fabric of life. We read signs, recipes, cereal boxes, e-mails, textbooks, directions, newspapers, labels, and other materials which facilitate our ability to lead independent, self-determined, and productive lives. People read and write to understand and express knowledge and ideas. In order to survive and thrive in the information age, people must be adept at accessing, examining, and exchanging information. Information is power, and in turn, literacy is empowerment. Unfortunately, not everyone has attained proficiency in literacy, and thus, not everyone can attain equal opportunity.

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Since formal education for students with visual impairments began, developing and promoting literacy has been a major objective. The first hurdle required the development of a formalized written communication system. Individuals had developed their own methods, such as carving notches in sticks, putting pinpricks in paper, tying knots on a rope, or sticking pins in pincushions (Harley, Truan, & Sanford, 1987). The next phase involved the replication of print letters. These replications came in the form of paper letters strung together to form words, 3-D wooden letters, cardboard letters, and cast iron letters (Harley et al., 1987). Unfortunately, all of these methods were cumbersome and did not facilitate large amounts of reading. Thus, the next major advancement involved embossing print letters on paper, which was first accomplished by hammering 3-D letters into wax tablets (Harley et al., 1987). This trend resulted in the development of several different large typefaces, and subsequently a great deal of debate ensued over which was most effective (Harley et al., 1987). However, it was a blind individual, Louis Braille, who made the point that tactile literacy is different than visual literacy, and hence, more was needed than merely replicating print in order for people who are blind and visually impaired to become effective and efficient readers.

After the adoption of braille as the official tactual code, following a prolonged period of experimentation with these different tactual codes, any student with a visual impairment, regardless of degree of residual vision, was taught to read and write using braille. It was believed that students with visual disorders should avoid using any remaining vision in order to prevent further deterioration of sight. This practice was known as sight saving, and it reigned as best practice until the concept of visual efficiency, or explicitly training students how to use their residual vision emerged (Barraga, 1963; Harley, et al., 1987; Rex, et al., 1994). Around this same time, a steady decline in the number of braille readers in the United States was noted (Nolan, 1965, 1969; Nolan & Bott, 1971). It was hypothesized in later years that this decline was the result of (a) an increase in the number of students who were labeled as non-readers due to additional disabilities, (b) an increase in the number of students with low-vision who use large print and optical aids, (c) limited availability of braille materials, (d) the predominant use of an itinerant service model, (e) insufficient teacher training, and (f) negative attitudes toward braille (Koenig, 1995; Schroeder, 1996; Spungin, 1996; Wittenstein, 1994). Currently, only nine percent of all legally blind students use braille as their primary reading medium (American Printing House for the Blind (APH), 2004). APH points out that 23% of all legally blind student readers use braille, thus suggesting that a large proportion of the population is considered non-readers. Regardless, the statistics are grim.

Literacy is related to other issues that face the field of visual impairments: caseload size, teacher shortages, and the changing population of students identified with visual impairments, many of whom have disabilities in addition to blindness. Shapiro (1993) also suggests that part of the literacy issue is related to a growing reliance on technology, although the National Reading Panel (2000) identified speech access, the use of hypertext, and the use of word processors as promising for the development of literacy. Some research suggests a link between post-school employment and braille literacy (Ryles, 1996; Schroeder, 1996), while other research suggests a relationship between hours of specialized instruction in braille and academic subject competence (Ferrell, 1993). Past discussions of the issue often deteriorate into emotional arguments, and more research is needed in order to identify both the factors that contribute to literacy and the source of statistics that seem to suggest the declining use of braille.

Ryles (1996) suggests that legally blind, braille readers attain higher education levels, employment rates, financial status, and self-esteem than legally blind, print readers. This study is often used to support the assertion that certain educational practices harm legally blind students and keep them from becoming literate adults. Since 74% of blind and visually impaired adults of working-age are unemployed or underemployed (Kirchner & Schmeidler, 1997), Ryles' conclusions are definitely a concern. In addition, results from statewide assessments show disturbing reading achievement levels for students with visual impairments. For example, only 41% of 10^{th} graders with visual impairments attained proficiency on the reading portion of the 2006 *Colorado Student Assessment Program* (CSAP) (Colorado Department of Education, 2006). Other states report similar results in grades 3 to 10 (see http://nclid.unco.edu/outcomes/). It is evident that students with visual impairments are not achieving adequate literacy, and they are not achieving it early enough in their lives.

Scientifically-Based Research

The No Child Left Behind Act (2002) requires the application of scientifically-based research to educational practice and defines it as "research that involves the application of rigorous, systematic, and objective procedures to obtain reliable and valid knowledge relevant to education activities and programs," including research that:

> (i) employs systematic, empirical methods that draw on observation or experiment;
> (ii) involves rigorous data analyses that are adequate to test the stated hypotheses and justify the general conclusions drawn;
> (iii) relies on measurements or observational methods that provide reliable and valid data across evaluators and observers, across multiple measurements and observations, and across studies by the same or different investigators;
> (iv) is evaluated using experimental or quasiexperimental designs in which individuals, entities, programs, or activities are assigned to different conditions and with appropriate controls to evaluate the effects of the condition of interest,

with a preference for random-assignment experiments, or other designs to the extent that those designs contain within-condition or across-condition controls;

(v) ensures that experimental studies are presented in sufficient detail and clarity to allow for replication or, at a minimum, offer the opportunity to build systematically on their findings; and

(vi) has been accepted by a peer-reviewed journal or approved by a panel of independent experts through a comparably rigorous, objective, and scientific review. (20 USC 7801, Sec. 9101(37)(B))

In the education of students with visual disabilities, it is not always possible to meet these strict criteria when conducting research. When strong scientifically-based research does not exist, Valentine and Cooper (2004) suggest that researchers produce syntheses of research summarizing the evidence pertaining to the effectiveness of educational interventions and approaches. The What Works Clearinghouse was established in 2002 by the US Department of Education to identify and disseminate the effectiveness of various educational interventions, primarily by conducting meta-analyses of the literature. The low prevalence of blindness and visual impairment makes it unlikely that the Clearinghouse will examine the body of literature in visual disabilities, and in fact, none of the topics currently under study involve students who are blind or visually impaired (see http://www.whatworks.ed.gov/topics/current_topics.html).

While the research foundation in blindness and low vision meets many of these scientifically-based research criteria, there is difficulty conducting studies with large enough samples to give confidence to the statistical procedures, that have been subject to repeated testing, or that utilize random assignment and control groups. The low-incidence nature of visual disability often limits the research designs that can be utilized and the conclusions that can be drawn. This has led to a research base characterized by single case studies, anecdotal reports, small and heterogeneous samples, and lack of replication. Perhaps because of these difficulties, educational research involving students with visual impairments is notoriously underfunded (Corn & Ferrell, 2000; Mason, Davidson, & McNerney, 2000), and individuals available to design and carry out educational research are often limited to a small number of faculty in less than 30 universities nationwide. These faculty (particularly those in programs with only one full-time faculty member) find that their research programs struggle for priority with their teaching, program coordination, recruiting, and service responsibilities. We are often left with best practices that are more philosophical than proven, more descriptive than empirical, and more antiquated than modern.

Many of the issues in literacy can and should be addressed by a systematic program of research that incorporates qualitative and quantitative designs. That does not appear likely to happen soon, given that there are too few researchers with too little money to address too many questions. Although much of the literature of the past decade has focused on braille literacy, scientifically-based research that might serve as a framework for best practices is rare.

The National Center's Analysis of the Literature in Literacy

The field of blindness and low vision finds itself in a position similar to the field of deaf education: We do not have a body of empirically-based, experimental research from which to draw research-based practices. When such strong "scientifically-based research" does not exist, it has been suggested that researchers produce syntheses of research summarizing the evidence pertaining to the effectiveness of educational interventions and approaches (Valentine & Cooper, 2004). One method often used for integrating a body of literature is meta-analysis.

Meta-analysis is a statistical procedure used to identify trends in the statistical results of a set of existing studies concerning the same research problem (Gall, Borg, & Gall, 2006). Through such a procedure, effects, which are hard or impossible to discern in the original studies because of too-small sample sizes, can be made visible, as the meta-analysis is equivalent to a single study with the combined effect size of all original studies. Meta-analytic reviews go beyond narrative reviews in the sense that they are systematic, explicit, and utilize quantitative methods of analysis (Rosenthal, 1991). Because of these features, meta-analytic reviews are considered to provide more thorough, comprehensive, and precise summative evaluations that entail greater objectivity than narrative reviews. Moreover, meta-analysis is consistent with American Psychological Association guidelines that call for use of effect sizes, which allows for an evaluation of the practical significance of differences. Consequently, the National Center on Low-Incidence Disabilities sought to conduct an exhaustive review of the literature and a meta-analysis of literacy research in the field of blindness and low vision. Literacy was operationally defined for purposes of this project as the ability to read and write in braille and/or print. Listening and aural comprehension also met the definition of literacy for this study (Tuttle, 1996).

Study Selection Criteria

For purposes of this study, literacy was defined as the ability to read and write. A three-step literature search strategy identified pertinent studies published from 1963 to 2003. First, manual searches for articles related to literacy and visual disabilities were conducted of all issues of the *Journal of Visual Impairment & Blindness* (formerly the *New Outlook for the Blind*) and *RE:view* (formerly *Education of the Visually Handicapped*). Second, computer searches in ERIC and PsychINFO were conducted. The search terms used were *braille*, *braille instruction*, *blind*, *blindness*, *visual impairment*, *partial vision*, *partially sighted*, *deaf blind*, *deafblind, deaf-blind*, *vision disorders*, *eye disorders*, *large type*, *low vision aids*, and, *optical aids*, cross-referenced with *literacy*, *reading*, and *writing*. Third, the reference list from every article identified in these searches was reviewed for additional articles. Late in the process, the team discovered a curriculum database maintained by Michener Library at the University of Northern Colorado, and additional potential studies were located there. A total of 652 articles were identified by this search process.

One study team member screened all 652 articles to identify those that met the following criteria:

1. The study was published in a peer reviewed journal published in English between 1963 and 2003.
2. Participants in the study were identified as students with a visual impairment of any degree (partial vision, low vision, partially sighted, blind).
3. Participants in the study were children and youth between 3 and 21 years of age.

After applying these three criteria, 405 articles remained. Of these, 174 were classified as practitioner articles (i.e., no data were presented, but a theory, belief, or practice was described and/or proposed), leaving 231 potential research studies that were further analyzed by the team. These 231 articles were reviewed independently by three team members, who determined whether the study reported:

1. A description of an intervention (which we defined as a systematic application of any program, product, practice, or policy with the intent of affecting an outcome);
2. A control group of some type; and
3. Data related to some aspect of literacy (the ability to read and write) as a dependent variable.

All three individuals had to agree that these criteria were met; where there were differences of opinion, the team members met to establish consensus. This process yielded 32 research studies that met the criterion for inclusion in the meta-analysis. A summary of the classification procedure is given in Table 1. Ten (10) articles did not report enough statistical information to permit computation of an effect size, and two (2) reported data that were contradictory to the conclusions drawn. Only 20 articles remained which met the criteria for inclusion in the study.

Data Analysis

Throughout this project, we applied the criteria developed by the What Works Clearinghouse (www.whatworks.ed.gov). While the evidence standards applied by the What Works Clearinghouse are often viewed as too strict or inappropriate for some types of research questions (see, for example, the Winter

2005 issue of *Exceptional Children*), application of these standards is a first step in determining how much confidence to place in the visual impairment literacy research and which studies yield best practice. We thus utilized the Study Design and Implementation Assessment Device (DIAD) (Valentine & Cooper, 2004) as a model for the development of our own study team DIAD. Because the What Works Clearinghouse had not yet developed DIAD elements for single subject designs, we added assessment options for Composite Questions 3 (clarity of causal inference) and 8 (precision of outcome). The DIAD used for this study is found in Appendix A.

After the DIAD was completed, the intervention and outcome measure was identified for each study. In addition, the effect sizes for each dependent variable were calculated. The effect size is a quantitative expression of the magnitude of the difference between the scores of the experimental and control groups. Specifically, it is the difference between two means (e.g., treatment minus control) divided by the pooled standard deviation of the two conditions (Thalheimer & Cook, 2002). While statistical tests of significance tell us the probability of the null hypothesis, effect-size measurements tell us the size of the experimental effect and allow us to compare the magnitude of experimental treatments from one experiment to another (Thalheimer & Cook, 2002). We can also think of effect size as a deviation from the null hypothesis, or how far the alternative hypothesis is from the null hypothesis (measured in standard deviations). Effect sizes have the same meaning across studies, even though studies use different measures and the scores have different score distributions (Glass, 1977). Effect size is used to review a set of quantitative research studies on a particular problem or it can be used as an aid to interpreting the results of a single study (Wilkinson, 1999).

Generally speaking, the effect size statistic is helpful in judging the practical significance of a research study. An effect size of 1.0 indicates that the treatment group mean was one standard deviation higher than the control group mean. Thus, the average participant in the experimental group performed at a level that was higher than approximately 84% of all participants in the control group. An effect size of 0 indicates that the treatment and control group means were identical, revealing the training had no effect. An effect size of 0.2 is considered small; an effect size of 0.5 is moderate; and an effect size of 0.8 or above is large (Cohen, 1992).

As previously stated, ten (10) of the 32 qualifying studies did not provide sufficient data with which to calculate an effect size and were therefore excluded from further analysis. Two additional studies were excluded because the conclusions asserted in the article were not supported by the data reported. We were able to compute the effect size for 20 studies using the statistics reported in each article.

The formula used to calculate an effect size for these 17 studies was $Cohen's\ d = \frac{\bar{X}_t - \bar{X}_c}{S_{pooled}}$, where the mean of the control group is subtracted from the mean of the treatment group, and the result is divided by the standard deviation of the two conditions (Thalheimer & Cook, 2002). In calculating effect size estimates for this study, the average scores were weighted by sample size according to procedures recommended by Hedges and Olkin (1985). Weighting was conducted because of the general tendency for treatment effects to be inversely related to sample size. We corrected for small sample sizes utilizing the following formula: $d' = d\left(1 - \left[\frac{3}{4N-9}\right]\right)$, where *d* is Cohen's *d*, above, and *N* is the number of study participants. If means and standard deviations were not reported, but an *F*-statistic was, the formula used was $d = \frac{\bar{X}_t - \bar{X}_c}{\sqrt{MSE\left(\frac{n_t + n_c - 2}{n_t + n_c}\right)}}$, where MSE is the mean square error, or $d = \sqrt{F\left(\frac{n_t + n_c}{n_t n_c}\right)\left(\frac{n_t + n_c}{n_t + n_c - 2}\right)}$, where F is the F statistic reported. If a *t*-statistic was reported, the formula used $d = t\sqrt{\left|\frac{n_t + n_c}{n_t n_c}\right|\left(\frac{n_t + n_c}{n_t + n_c - 2}\right)}$ (Thalheimer & Cook).

Seven (7) of the qualifying studies utilized single subject research designs, but only 3 provided sufficient data for analysis. We used the method recommended by Scruggs and Mastropieri (2001; see also Scruggs, Martriopieri & Casto, 1987) for calculating effect sizes, which divides the number of data points that exceed the extreme value in the baseline condition by the total number of intervention data points. Using the graphs provided by the authors, we placed a ruler horizontally across the graph at the highest baseline value, then counted the number of data points during intervention that were visible above the ruler. The result was divided by the total number of intervention data points, yielding a proportion that as then labeled as the effect size.

The Studies

The 20 studies that qualified for analysis are presented in Table 2. Studies are listed alphabetically, and at least one intervention and outcome is listed for each study. Many of the studies measured multiple interventions and outcomes. Often, an author grouped multiple experiments into one article, but it was clear that the same subject pool was being utilized repeatedly, and in such cases, only the first experiment reported was included in this analysis because of the threat to internal validity. It is clear from Table 1 that, although many outcome measures were similar (e.g., oral and/or silent comprehension; reading speed), no two interventions were alike.

Table 2 describes the participants included in these 20 studies. In many cases, pertinent information about the students being studied was omitted from the article (and left blank in the table) or was reported ambiguously. Visual ability, for example, was rarely identified by acuity; in Table 2, we have included other information from the article that might give an indication of visual functioning. While the participants were almost certainly visually impaired, the absence of precise near point acuities opens the possibility that the individuals being studied displayed visual behaviors that exceeded the generalizations made by the authors. More recent studies (e.g., Corn, Wall, & Bell, 2001 and Smith & Erin, 2002) report more precise information about visual acuity.

Table 2 also demonstrates that the qualifying studies often failed to describe other pertinent characteristics of the samples studied. Full-scale IQ, gender, multiple disability status, and sometimes even age were omitted. The educational setting, of course, provided an approximation of the subjects' ages. The ages reported ranged from a mean of 9 to a mean of 16.7 years. Fifteen (15) studies selected participants from specialized schools. In some studies (generally those conducted earlier), only specialized schools were utilized, while more recent studies were conducted in general education or a combination of specialized and general education settings. Those studies that addressed the multiple disability status of their participants generally established "no additional disabilities" as a criterion for study inclusion. The sample size of these 20 studies ranged from 3-6 participants for the single subject designs, to 10-72 for the quantitative designs.

Table 3 reports the findings and effect sizes for the 20 qualifying studies, arranged by decreasing effect size in 11 broad outcome categories of aural comprehension; haptic memory; braille reading speed; braille reading achievement; braille reading comprehension; braille reading skills; braille writing; print reading comprehension; print reading speed; amount of print reading; and print recognition. If a study had multiple outcomes, some of which would be considered trivial for educational studies (Hopkins, 2002), only the outcomes greater than .20 (considered a small effect) are reported. Two articles are reported in Table 2 even though their effect sizes were smaller than .20 (Gardner, 1985; Koenig & Ashcroft, 1984).

Relationship to the National Reading Panel's Recommendations

Preliminary results of our analysis are presented here in terms of four of the five components of reading identified by the National Reading Panel (NRP) (2000). (Teacher education in reading instruction, the fifth component, was not considered in this analysis because we were examining interventions with children.)

Alphabetics

The first component of literacy identified by the National Reading Panel is alphabetics, which includes phonemic awareness and phonics. Phonemic awareness is the ability to manipulate the smallest sounds of spoken language, whereas phonics refers to the letter-sound relationship and includes an understanding that spoken words are composed of tiny sound segments or phonemes (National Reading Panel, 2000). While several studies addressed some component of alphabetics, only two (Mangold, 1978; Umsted, 1972) met the standards for inclusion in the meta-analysis. These two studies examined braille code recognition, but it is not clear whether a phonemic approach was used. There is limited evidence, either for print or braille readers, that a phonemic approach contributes to literacy. (On the other hand, there is no evidence to the contrary.) Alphabetics appears to be a component of reading that has received little attention, perhaps because it seems obvious (the sound is naturally paired with the orthographic representation, whether print or braille), or perhaps because its value has been generalized from research on children without disabilities and simply accepted as good practice. Given that contracted braille does not have a one-to-one phonemic correspondence (contractions range from whole words to parts of words, including one or more syllables), the study of phonemic awareness in children who are blind or who have low vision should not be relegated to generalization from a sighted population.

Fluency

Fluency is the ability to "read orally with speed, accuracy, and expression" (National Reading Panel, 2000, p. 11). Eight studies addressed some component of fluency, either reading speed or reading mechanics (e.g., retracings, letter skippings, use of low vision devices, use of specific finger, degraded braille, telegraphic deletions) (Corn, Wall, & Bell, 2001; Flanagan, 1966; Hermelin & O'Connor, 1971; Kederis, Nolan & Morris, 1967; Mangold, 1978; Martin & Bassin, 1977; Millar, 1987; Umsted, 1972). One study examined the amount of reading by measuring the total number of pages read in various types of books (Lackey, Efron, & Rowls, 1983). Because none of the interventions were replicated, only limited conclusions can be drawn: (a) automated practice in braille reading improves reading speed and decreases errors in braille code recognition; and (b) use of low vision devices appears to increase reading speed and amount of reading.

Comprehension

The third element of literacy is comprehension, which involves vocabulary instruction, text comprehension instruction, and teacher preparation and comprehension strategies instruction (National Reading Panel, 2000). Six of the studies included in this analysis addressed comprehension (Brothers, 1971; Corn, Wall, & Bell, 2001; Millar, 1990; Kederis, Nolan, & Morris, 1967; Martin &

Bassin, 1977; Umsted, 1972). Typically, the studies examined understanding of reading passages when material was deleted; when training was automated (e.g., use of a braille tape reader or other machine); when low vision devices were used; when assessment of comprehension was delayed; or when reading was confounded by competing auditory or tactile stimuli. None of the qualifying studies examined vocabulary instruction or teacher preparation. Again, only limited conclusions can be made: (a) automated practice in braille reading improves comprehension; and (b) use of low vision devices may contribute to increased comprehension.

Computer Technology

Another aspect of literacy identified by the NRP involves the use of computers to teach reading. While our literature review identified a number of articles regarding assistive technology for students with visual impairments, computers were usually introduced after reading and writing had been mastered. Only two studies were remotely related to computer technology (Flanagan, 1966; Kederis, Nolan, & Morris, 1967); as might seem obvious from their date of publication, these studies examined more primitive forms of technology that are generally not in use today. The methods utilized today to teach blind children to read are essentially the same as those used in the 1950s. But classrooms are different and continuously changing:

> The challenge facing America's schools is the empowerment of all children to function effectively in their future, a future marked increasingly with change, information growth, and evolving technologies. Technology is a powerful tool with enormous potential for paving high-speed highways from outdated educational systems to systems capable of providing learning opportunities for all, to better serve the needs of 21st century work, communications, learning, and life. (Thomas, 2003)

The National Center for Education Statistics' Early Childhood Longitudinal Study reports that 97% of kindergarten students with disabilities and 98% of first graders with disabilities use computers (Rathbun & West, 2003). Furthermore, Rathbun and West report that in first grade, "children with disabilities were less likely to have access to home computers than children without disabilities" (p. 24), although 87% of those who did actually used their home computers for educational purposes for an average of 3.5 days per week. In the classroom, children used computers most frequently to read, write, spell, learn math, and for fun. It appears that the future is here, but our teaching methodologies have not yet arrived.

<u>Promising Practices</u>

Identifying promising practices from a diverse group of studies that have never been replicated is somewhat of risky. Nevertheless, they do suggest that the following practices *may* be effective in teaching students with visual impairments.

1. Braille readers may be better able to process oral information than large print readers (Brothers, 1971).

2. Haptic perception is sustained over time (Anater, 1980), suggesting that concrete hands-on experiences might enhance learning.

3. Reading braille with the left hand may be more effective than with the right hand (Hermelin & O'Conner, 1971).

4. Reducing the number of words in a braille reading passage may not result in increased speed or comprehension (Martin & Bassin, 1977).

5. Poor braille quality can slow down reading rate and accuracy (Miller, 1977, 1987).

6. Leaving out words might decrease the amount of time it takes to read, but it does not increase comprehension (although it has a greater impact on news passages than it does on science or fiction passages) (Martin & Bassin, 1977).

7. Drill and practice in braille can lead to increased reading achievement, faster silent and oral reading rates, fewer reading errors, and greater comprehension (Flanagan, 1966; Flanagan & Joslin, 1969; Kederis, Nolan, & Morris, 1967; Layton & Koenig, 1998; Mangold, 1978; Umsted, 1972).

8. Braille reading comprehension is decreased when other stimuli compete for the student's attention (Millar, 1988, 1990).

9. Training in and use of low vision devices increases oral comprehension reading speed (oral and silent), and the amount of reading accomplished (Corn, Wall, & Bell, 2001; LaGrow, 1981; Lackey, Efron, & Rowls, 1982; Smith & Erin, 2002)

<u>Limitations</u>

Any time an analysis of this scope is undertaken, there are undoubtedly errors in judgment and errors in fact. It is possible that our extensive searching did not locate every research study in literacy for students with visual impairments. In addition, some researchers may feel offended by our somewhat stringent application of the What Works Clearinghouse evidence standards that resulted in their research being omitted from our analysis. Our goal in undertaking this project was to take a hard look at what we knew and what we needed to know more about. From this perspective, this analysis should be viewed as the beginning of a larger investigation into evidenced-based and promising practices and not as the final product.

Concluding Thoughts

Studies conducted in the 1960s and 1970s used more rigorous approaches than are used today. In part, this may be due to the trend toward qualitative designs, but even those studies employing quantitative methods sometimes failed to meet basic design standards that would lend confidence to the results. Unfortunately, the rigorous designs of the past fall short by current standards, particularly given the lack of description of sample characteristics and the tendency to use the same sample repeatedly. While we can empathize with the desire to save money by employing an existing sample, it cannot help but contaminate the results and the ability to generalize to the larger population.

In an effort to examine general strengths and weaknesses in the 20 qualifying studies, Table 4 presents the mean rank for each element of the DIAD. A value of three (3) indicated the highest standard of evidence, where studies appeared to be strongest in terms of the intervention's relevance to the review, the outcome measure's relevance to the review, and the clarity of causal inference for randomized designs (only seven studies utilized randomized designs). None of the qualifying studies utilized regression discontinuity designs (The basic regression discontinuity design is a two-group, pretest-posttest model, where one group receives a treatment and the other group does not. The only difference from other pre/post test designs is that the regression discontinuity participants are placed into conditions based on a score not randomly.). Other areas of causal inference seemed to rank lower than randomized designs – suggesting either the strength of the randomized study or the relative weakness of the other studies. The studies ranked less high for generality of findings, perhaps due to the lack of specificity in participants mentioned earlier. None of the articles computed effect sizes in the publication, but enough statistics were reported to allow us to calculate effect sizes.

Many studies, even ones that qualified for this analysis, failed to include pertinent information about the participants in the study. While omitting gender and additional disability status might be attributable to historical social conventions and the changing population of students with visual impairments, articles were also missing information about the ages of participants, their levels of visual function, their cognitive abilities, and their visual disorders. This information is critical to determine generalizability and to understand the results. As Odom et al. (2005) state, "Researchers cannot just address a simple question about whether a practice in special education is effective; they must specify clearly for whom the practice is effective and in what context" (p. 141).

The literature contains studies comparing students with visual disabilities to those with typical vision and those with other disabilities. Some studies that included sighted participants also employed the practice of occluding vision. These are not appropriate comparison groups, and only results in descriptions of the difference between apples and oranges (see Warren, 1994). Consequently, these studies were excluded from the analysis (see, for example, Pring, 1984).

We do not appear to follow a systematic program of research, either as a field or as individuals. The work seems at times disjointed from real issues of literacy as identified by the National Reading Panel (2000) and attends to minute details that are inconsequential to the larger issues of, for example, comprehension and fluency. Further, one study on one intervention frequently establishes “effective practice” for students with visual disabilities, when few results have ever been validated by replication studies. The few replications that do exist contradict the original study or create additional questions that should be addressed (see, for example, Gardner, 1985; Hermelin & O’Connor, 1971). As Slavin (2002) stated, “The hallmark of science is organized, disciplined inquiry that gives the null hypothesis every consideration” (p. 18).

Experimental designs with low-incidence populations are not easy to do. The heterogeneous nature of the population, where students with the same eye condition or even acuity seldom perform similarly and where visual function varies depending on the task, time of day, and environmental conditions, makes it difficult to create equivalent groups. Further, as the term implies, low-incidence means that a small number of individuals are dispersed throughout any given geographic area. The *25th Annual Report to Congress* (U.S. Department of Education, 2005) reports that students with visual impairments served under the Individuals with Disabilities Education Act comprise less than one-half of one percent of the estimated school-age population in the United States. Creating equivalent groups requires multiple schools, districts, and states, which in turn requires increased levels of funding for travel and personnel.

Several excellent texts provide guidance to parents and teachers on literacy strategies that together may contribute to a body of best or promising practice for the field of visual impairment (Koenig & Holbrook, 2000; Wormsley, 2004; Wormsley & D’Andrea, 1997). However, few of these strategies have been tested systematically, and as such, they create the roadmap for the next phase of literacy research.

Scientifically-based research is not the only type of research for examining the literacy behaviors of students with visual impairments. The January 2005 issue of *Exceptional Children* includes several articles on research methodologies in special education, including experimental and quasi-experimental studies (Gersten et al., 2005), single-subject designs (Horner et al., 2005), correlational designs (Thompson et al., 2005), and qualitative studies (Brantlinger et al., 2005).

The field of visual impairment espouses techniques, procedures, curricula, and service delivery options without evidence, or based on the lowest level of evidence, over and over again. The field needs to challenge its assumptions, examine its procedures, and pursue alternative explanations for every study. Until we do so, “we are merely riding the pendulum of educational fashion” (Slavin, 2002, p. 19).

References

References marked with an asterisk indicate studies included in the meta-analysis.

American Printing House for the Blind. (2004). Distribution of eligible students based on the federal quota census of January 6, 2003 (fiscal year 2004). Retrieved April 7, 2005 from http://www.aph.org/fedquotpgm/dist03.html

*Anater, P. F. (1980). Effects of auditory inference on memory of haptic perceptions. *Journal of Visual Impairment & Blindness, 74*, 305-309.

Barraga, N. (1963). Mode of reading for low vision students. *International Journal for the Education of the Blind, 12*, 107-107.

Brantlinger, E., Jimenez, J., Klingner, J., Pugach, M., & Richardson, V. (2005). Qualitative studies in special education. *Exceptional Children, 71*, 195-207.

*Brothers, R. J. (1971). Learning through listening: A review of the relevant factors. *New Outlook for the Blind, 65*, 224-231.

Cohen, J. (1992). A power primer. *Psychological Bulletin, 112*, 155-159.

Colorado Department of Education. (2006). CSAP summary data 1997-2006. Retrieved December 13, 2006 from http://www.cde.state.co.us/cdeassess/documents/csap/csap_summary.html

Corn, A. L., & Ferrell, K. A. (2000). External funding for training and research in visual disabilities at colleges and universities, 1997-98. *Journal of Visual Impairment & Blindness, 94,* 372-384.

*Corn, A., Wall, R., & Bell, J. (2001). Impact of optical devices on reading rates and expectations for visual functioning of school age children and youth with low vision. *Visual Impairment Research, 2,* 33-41.

Ferrell, K. A. (1993). *Educational outcomes for Colorado students with visual handicaps: Preliminary report.* Greeley, CO: University of Northern Colorado, Division of Special Education.

*Flanagan, P. J. (1966). Automated training and braile reading. *New Outlook for the Blind, 60*, 141-146.

*Flanagan, P. J., & Joslin, E. S. (1969). Patterns of response in the perception of braille configurations. *New Outlook for the Blind, 63,* 232-244.

Gall, M. D., Borg, W. R., & Gall, J. P. (2006). *Educational research: An introduction* (8th ed., rev'd.). Upper Saddle River, NJ: Pearson Education.

*Gardner, L. R. (1985). Low vision enhancement: The use of figure-ground reversals with visually impaired children. *Journal of Visual Impairment & Blindness, 79,* 64-69.

Gersten, R., Fuchs, L. S., Compton, D., Coyne, M., Greenwood, C., & Innocenti, M. S. (2005). Quality indicators for group experimental and quasi-experimental research in special education. *Exceptional Children, 71*, 149-164.

Glass, G. V. (1977). Integrating findings: The meta-analysis of research. *Review of Research in Education, 5*, 351-379.

*Harley, R. K., & Rawls, R. (1970). Comparison of several approaches for teaching braille reading to blind children. *Education of the Visually Handicapped, 2*(2), 47-51.

Harley, R. K., Truan, M. B., & Sanford, L. D. (1987). *Communication skills for visually impaired learners*. Springfield, IL: C. Charles Thomas Publisher

Hedges, L. V., & Olkin, I. (1985). *Statistical methods for meta-analysis*. San Diego: Academic Press.

*Hermelin, B., & O'Connor, N. (1971). Right and left-handed reading of braille. *Nature, 231*, 470.

Hopkins, W. G. (2002). A scale of magnitude for effect sizes. In *A new view of statistics*. Accessed June 16, 2006, at http://file:///I:/Literacy%20Meta-Analysis/HyperStat%20Online%20Measuring%20Effect%20Size.htm

Horner, R. H., Carr, E. G., Halle, J., McGee, G., Odom, S., & Wolery, M. (2005). The use of single-subject research to identify evidence-based practice in special education. *Exceptional Children, 71*, 165-179.

*Kederis, C. J., Nolan, C. Y., & Morris, J. E. (1967). The use of controlled exposure devices to increase braille reading rates. *International Journal for the Education of the Blind, 16*(4), 97-105.

Kirchner, C., & Schmeidler, E. (1997). Prevalence and employment of people in the United States who are blind or visually impaired. *Journal of Visual Impairment & Blindness, 91*, 508-511.

Koenig, A. J. (1995). Can reading and writing braille be taught on an itinerant basis? *Journal of Visual Impairment & Blindness, 89*, 101-102.

*Koenig, A. J., & Ashcroft, S. C. (1983). Initial assessment of student use of the electric Perkins Brailler. *Education of the Visually Handicapped, **15***(2), 59-66.

Koenig, A. J., & Holbrook, M. C. (2000). Literacy skills. In A. J. Koenig & M. C. Holbrook (Eds.), *Foundation of education: Instructional strategies for teaching children and youths with visual impairments* (2nd ed.) (pp. 264-329). New York: AFB Press.

*Lackey, G. H., Efron, M., & Rowls, M. D. (1982). For more reading: Large print books or the Visolett? *Education of the Visually Handicapped, 14*(3), 87-94.

*LaGrow, S. J. (1981). Effects of training on CCTV reading rates of visually impaired students. *Journal of Visual Impairment & Blindness, 75*, 368-375.

*Layton, C. A. & Koenig, A. J. (1998). Increased reading fluency in elementary students with low vision through repeated readings. *Journal of Visual Impairment & Blindness, 92,* 276-292.

*Mangold, S. S. (1978). Tactile perception and braille letter recognition: Effects of developmental teaching. *Journal of Visual Impairment & Blindness, 72*, 259-266.

*Martin, C. J., & Bassin, C. B. (1977). Effects of two telegraphic deletion schemes on the reading behavior of braille readers. *Journal of Special Education, 11*, 233-241.

Mason, C., Davidson, R., & McNerney, C. (2000). *National plan for training personnel to serve children with blindness and low vision.* Reston, VA: The Council for Exceptional Children.

*Millar, S. (1977). Tactual and name matching by blind children. *British Journal of Psychology, 68,* 377-387.

*Millar, S. (1985). The perception of complex patterns by touch. *Perception, 14,* 293-303.

*Millar, S. (1987). Perceptual and task factors in fluent braille. *Perception, 16,* 521-536.

*Millar, S. (1988). Prose reading by touch: The role of stimulus quality, orthography, and context. *British Journal of Psychology, 79*(1), 87-103.

*Millar, S. (1990). Articulatory coding in prose reading: Evidence from braille on changes with skill. *British Journal of Psychology, 81*, 205-219.

National Reading Panel. (2000). Report of the National Reading Panel: Teaching children to read: An evidenced-based assessment of the scientific research literature on reading and its implications for reading instruction. Washington D.C.: National Institute for Literacy.

No Child Left Behind Act of 2001, 20 U.S.C. §6301 et seq. Text from: *United States Code Service*. Available from: *LexisNexis™ Congressional (Online Service)*. Bethesda, MD: Congressional Information Service.

Nolan, C. Y. (1965). Blind children, degree of vision, mode of reading: A 1963 replication. *New Outlook for the Blind, 59*, 233-238.

Nolan, C. Y. (1967). A 1966 reappraisal of the relationship between visual acuity and mode of reading for blind children. *New Outlook for the Blind, 61*, 255-261.

Nolan, C. Y., & Bott, J. E. (1971). Relationships between visual acuity and reading medium for blind children-1969. *New Outlook for the Blind, 65*, 90-96.

Odom, S. L., Brantlinger, E., Gersten, R., Horner, R. H., Thompson, B., & Harris, K. R. (2005). Research in special education: Scientific methods and evidence-based practices. *Exceptional Children, 71*, 137-148.

Pring, L. (1984). A comparison of the word recognition processes of blind and sighted children. *Child Development, 55*(5), 1865-1877.

Rathbun, A. H., & West, J. (2003). *Young children's access to computers in the home and at school in 1999 and 2000 (NCES 2003-036).* Washington, DC: U.S. Department of Education, National Center for Education Statistics.

Rex, E. J., Koenig, A. J., Wormsley, D. P., & Baker, R. L. (1994). *Foundations of braille literacy*. New York: AFB Press.

Rosenthal, R. (1991). *Meta-analytic procedures for social research* (rev. ed.). Newbury Park, CA: Sage Publications.

Ryles, R. (1996). The impact of braille reading skills on employment, income, education, and reading habits. *Journal of Visual Impairment & Blindness, 90,* 219-26.

Schroeder, F K. (1996). Perceptions of braille usage by legally blind adults. *Journal of Visual Impairment & Blindness, 90,* 210-18.

Scruggs, T. E., & Mastropieri, M. A. (2001). How to summarize single-participant research: Ideas and applications. *Exceptionality, 9*, 227-244.

Scruggs, T. E., Mastropieri, M. A., & Casto, G. (1987). The quantitative synthesis of single subject research: Methodology and validation. *Remedial and Special Education, 8*(2), 24-33.

Shapiro, J. P. (1993). *No pity.* New York: Times Books, Random House.

Slavin, R. E. (2002). Evidence-based education policies: Transforming educational practice and research. *Educational Researcher, 31*(7), 15-21.

*Smith, J. K., & Erin, J. N. (2002). The effects of practice with prescribed reading glasses on students with low vision. *Journal of Visual Impairment & Blindness, 96*, 765-782.

Spungin, S. J. (1996). Braille and beyond: Braille literacy in a larger context. *Journal of Visual Impairment & Blindness, 90,* 271-274.

*Sykes, K. C. (1971). A comparison of the effectiveness of standard print in facilitating the reading of visually impaired students. *Education of the Visually Handicapped, 3*(4): 97-106.

Thalheimer, W., & Cook, S. (2002). How to calculate effect sizes from published research articles: A simplified methodology. Retrieved January 9, 2005 from http://work-learning.com/effect_sizes.htm

Thomas, L. G. (2003). *The NETS project. In International Society for Technology in Education,* National Educational Technology Standards Project. Retrieved April 11, 2003, from http://cnets.iste.org/nets_overview.html

Thompson, B., Diamond, K. E., McWilliam, R., Snyder, P., & Snyder, S. W. (2005). Evaluating the quality of evidence from correlational research for evidence-based practice. *Exceptional Children, 71*, 181-194.

U.S. Department of Education, Office of Special Education and Rehabilitative Services, Office of Special Education Programs. (2005). *Twenty-fifth annual (2003) report to Congress on the implementation of the Individuals with Disabilities Education Act.* Washington, DC: U.S. Department of Education.

*Umsted, R. G. (1972). Improving braille reading. *New Outlook for the Blind, 66*, 169-177.

Valentine, J. C., & Cooper, H. (2004). *What Works Clearinghouse study design and implementation assessment device* (Version 1.1). Washington, DC: U.S. Department of Education.

Warren, D. H. (1994). *Blindness and children: An individual differences approach*. Cambridge: Cambridge University Press.

What Works Clearinghouse (2006, February). *What works clearinghouse study review standards*. Retrieved July 12, 2006 at http://www.whatworks.ed.gov/reviewprocess/standards.html

Wilkinson, L. (1999). Statistical methods in psychology journals: Guidelines and explanations (Task Force on Statistical Inference). *American Psychologist*, *54*(8), 594-604.

Wittenstein, S. H. (1994). Braille literacy: Preservice training and teachers' attitudes. *Journal of Visual Impairment & Blindness, 88*, 516-524.

Wormsley, D. P. (2004). *Braille literacy: A functional approach*. New York: AFB Press.

Wormsley, D. P., & D'Andrea, M. (Eds.). (1997). *Instructional strategies for braille literacy*. New York: AFB Press.

Table 1. Classification of Literacy Literature

Criterion	Number	Proportion
Peer-reviewed, published in English	652	
Did not examine students between 3 and 21 years	212	.325
Included participants with disabilities other than blindness or low vision (e.g., learning disabilities)	27	.041
Included a sighted comparison group	8	.012
Practitioner	174	.267
No comparison group/no intervention	95	.146
Did not meet definition of literacy	97	.149
Could not locate	7	.011
Qualified for this analysis	32	.049
Total:		1.000

Table 2. Description of Study Participants in Qualifying Studies

Author(s)	Visual Ability	Cognitive Ability	Average Age	Gender (Proportion Female)	Educational Setting	Multiple Disability	Number of Participants
Anater (1980)	Blind before age 2; light projection or less	"Average"	Range 8-20 years	NR[4]	5 midwest residential schools	NR	61
Brothers (1971)	Legally blind; "55% read braille . . . 45% used large type"	100.5	NR	NR	Grades 9-12, 1 specialized school,	NR	40
Corn, Wall, & Bell (2001)	20/40 to 20/600	NR	10.05	NR	Grades P- 12, multiple public & private schools and 1 specialized school,	NR	65
Flanagan (1966)	"functional braille readers"	101.5	14.2	NR	elementary and junior high at 1 specialized school	NR	30

[4] Not reported in article.

Author(s)	Visual Ability	Cognitive Ability	Average Age	Gender (Proportion Female)	Educational Setting	Multiple Disability	Number of Participants
Flanagan & Joslin (1969)	NR	100.8	13	NR	Grades 3 - 9+, 1 specialized school,	NR	26
Gardner (1985)	20/70 to 20/200	"Normal"	11.92	NR	City, suburban, and rural New Jersey	No other handicapping condition	18
Hermelin & O'Conner (1971)	"braille readers"	NR	9	NR	NR	NR	13
Kederis, Nolan, & Morris (1967)	NR	NR	NR	.47 to.70	Grades 6-12, 1 specialized school; grades 5-11, 2nd specialized schools	NR	62
Koenig & Ashcroft (1983)	"major reading medium is braille"	NE	13.4	.50	Grades 1-12, 1 specialized school	2 Ss 4-5 years below expected grade level	10

Author(s)	Visual Ability	Cognitive Ability	Average Age	Gender (Proportion Female)	Educational Setting	Multiple Disability	Number of Participants
Lackey, Efron, & Rawls (1982)	“partially blind;” “uncomfortable with normal size print”	NE	13.04	NR	Grades 4-5 and 7-9, regular classrooms	None	55
LaGrow (1981)	LP to 20/400	NR	16.5 yrs.	.33	junior and senior high school	NR	6
Layton & Koenig (1998)	"low vision but not functionally blind"	"average range"	9.25	.75	"mainstreamed" in public and private schools	NR	4
Mangold (1978)	“legally blind braille users”	NR	10	.75	1/3 at 1 specialized school; 2/3 in 17 public school resource & itinerant programs	NR	30
Martin & Bassin (1977)	“minimum 4 years of braille instruction”	104.53	NR	NR	Grades 8-12, 1 specialized school	NR	36
Millar (1977)	Totally blind or minimal light perception from birth-20 months	“low average to superior intelligence”	10.2	.42	2 specialized high schools	NR	12

Author(s)	**Visual Ability**	**Cognitive Ability**	**Average Age**	**Gender (Proportion Female)**	**Educational Setting**	**Multiple Disability**	**Number of Participants**
Millar (1987)	“relied solely on braille for their academic work”	NR	17	NR	2 specialized high schools	NR	18
Millar (1988)	“exclusive use of braille for higher level academic achievements”	NR	17	NR	2 specialized high schools	NR	18
Millar (1990)	“considered by instructors to use only braille for reading”	NR	15	.48	1 specialized school	NR	21
Smith & Erin (2002)	20/100 to 20/240	NR	16.7	.33	Grades 10 & 11, 1 specialized school	NR	3
Umsted (1972)	“used braille as primary reading medium”	NR	NR	NR	high school, 3 midwest specialized schools	None	72

Table 3. Studies, Findings, and Effect Sizes

Author(s)	Description of Findings	Adjusted Effect Size
	Aural Comprehension:	
Brothers, 1971	Comprehension of aural reading is greater when tested immediately after exposure, regardless of message length or reading medium.	.93 (large)
Brothers, 1971	Comprehension of aural reading after a period of delay is greater for braille readers than for large type readers, regardless of message length.	.67 (moderate)
Brothers, 1971	Comprehension of aural reading tested immediately after exposure is greater for braille readers than for large type readers, regardless of message length.	.53 (moderate)
	Haptic Memory:	
Anater, 1980	Haptic information processed independently of auditory interference	.80 (large)
	Braille Reading Speed:	
Hermelin & O'Conner, 1971	Braille reading is faster with the left hand than with the right hand.	1.83 (very large)
Martin & Bassin, 1977	Fiction passages in reduction conditions decrease reading rate (words/minute).	1.36 (very large)
Miller, 1987	Degraded braille cells reduce silent reading rate.	1.24 (very large)
Umsted, 1972	Braille code recognition training increases silent reading rate.	1.06 (large)
Layton & Koenig, 1998	Oral reading speed increased during repeated readings to criterion.	.65 (moderate)

Author(s)	Description of Findings	Adjusted Effect Size
Martin & Bassin, 1977	Science passages in reduction conditions decreases reading rate (words/minute).	.64 (moderate)
Flanagan, 1966	Paced reading practice with braille tape reader increases braille reading speed.	.48 (small)
Umsted, 1972	Training in braille code recognition increases accuracy in oral reading rate.	.45 (small)
Martin & Bassin, 1977	News passages in reduction conditions decrease reading rate.	.35 (small)
	Braille Reading Achievement	
Flanagan, 1966	Paced reading practice with braille tape reader increases reading achievement levels.	.29 (small)
	Braille Reading Comprehension:	
Millar, 1988	Reading aloud with articulatory suppression decreases comprehension.	1.97 (very large)
Millar, 1990	Reading aloud while foot tapping decreases comprehension.	.50 (moderate)
Martin & Bassin, 1977	News passages in reduction conditions decrease comprehension.	.43 (small)
Kederis, Nolan, & Morris, 1967	Paced reading with IBM Braille Reading Machine increases comprehension scores.	.22 (small)
	Braille Reading Skills	
Millar, 1977	Greater accuracy in matching paired cells of standard size than enlarged cells.	3.57 (huge)
Millar, 1987	Greater accuracy when finger is oriented to braille cell in standard manner.	2.03 (huge)

Author(s)	Description of Findings	Adjusted Effect Size
Flanagan, 1966	Paced reading practice with braille tape reader decreases number of retracings.	1.97 (very large)
Martin & Bassin, 1977	News passages in reduction conditions decrease amount of reading time.	1.08 (large)
Mangold, 1978	Training in Mangold programs increases overall tactile and braille recognition scores.	1.02 (large)
Martin & Bassin, 1977	Science passages in reduction conditions decrease amount of reading time.	.62 (moderate)
Flanagan, 1966)	Paced reading practice with braille tape reader decreases vertical movements.	.62 (moderate)
Flanagan, 1966	Paced reading practice with braille tape reader decreases verbal errors.	.61 (moderate)
Umsted, 1972	Training in braille code recognition decreases errors.	.54 (moderate)
Layton & Koenig, 1998	Repeated readings to criterion increased recognition of content words.	.43 (small)
Layton & Koenig, 1998	Repeated readings to criterion decreased error rates.	.39 (small)
Flanagan & Joslin, 1969	Reading practice with programmed tachtistoscopic device decreases errors.	.36 (small)
Layton & Koenig, 1998	Recognition of content words maintained after intervention (repeated readings to criterion).	.22 (small)
	Braille Writing	
Koenig & Ashcroft, 1983	The Electronic Perkins Braillewriter may decrease overall braille writing rate.	-0.116 (trivial)

Author(s)	Description of Findings	Adjusted Effect Size
Koenig & Ashcroft, 1983	The Electronic Perkins Braillewriter may increase spelling errors.	0.083 (negligible)
Koenig & Ashcroft, 1983	The Electronic Perkins Braillewriter may increase total braille writing accuracy.	0.071 (negligible)
Koenig & Ashcroft, 1983	The Electronic Perkins Braillewriter may decrease capitalization, punctuation, and spacing errors.	0.017 (negligible)
	Print Reading Comprehension	
Corn, Wall, & Bell, 2001	Instruction in use of low vision devices increases oral comprehension.	.52 (moderate)
	Print Reading Speed	
LaGrow, 1981	Increased reading speed following training with CCTV.	.84 (large)
LaGrow, 1981	Increase in reading speed without CCTV, following CCTV training.	.51 (moderate)
Corn, Wall, & Bell, 2001	Instruction in use of low vision devices increases oral reading speed.	.36 (small)
Smith & Erin, 2002	Increase in oral reading rate (words/minute) following instruction and practice with prescription reading glasses.	.34 (small)
Smith & Erin, 2002	Increase in silent reading rate (words/minute) following instruction and practice with prescription reading glasses.	.26 (small)
Corn, Wall & Bell, 2001	Instruction in use of low vision devices increases silent reading speed.	.22 (small)

Author(s)	Description of Findings	Adjusted Effect Size
	Amount of Print Reading	
Lackey, Efron, & Rowls, 1982	Increase in total number of pages (.74), total number of books read (.55), number of non-school books (.40), and number of school books (.34), by 7-9th graders when using low vision devices.	.74 (moderate) .55 (moderate) .40 (small) .34 (small)
Lackey, Efron, & Rowls, 1982	Increase in total number of school books (.69), total number of books (.67), and number of non-school books (.36) read by 4th and 5th graders when using low vision devices.	.69 (moderate) .67 (moderate) .36 (small)
	Print Recognition	
Gardner, 1985	Yellow print on black background slightly increased subjects' ability to identify increasingly smaller print.	0.12 (trivial effect)
Gardner, 1985	White print on black background did not increase subjects' ability to identify increasingly smaller print.	0.06 (negligible effect)

Table 4. Mean Study Design and Implementation Assessment Device (DIAD) Ratings for Literacy Studies

Study Design Elements (DIAD)	Mean Rank[5]	N
Composite Question 1. Intervention's Relevance to the Review: Was the intervention properly defined?	2.9	20
Composite Question 2. Outcome Measure's Relevance to the Review: Was the outcome measure properly defined and aligned to the intervention?	3.0	20
Composite Question 3a. Clarity of Causal Inference: Fair Comparison (for Randomized Designs): Were the participants (e.g. students, schools) in the group receiving the intervention comparable to the participants in the comparison group?	2.9	7
Composite Question 3b. Clarity of Causal Inference: Fair Comparison (for Quasi-Experimental Designs): Were the participants (e.g. students, schools) in the group receiving the intervention comparable to the participants in the comparison group?	1.3	3
Composite Question 3c. Clarity of Causal Inference: Fair Comparison (for Regression Discontinuity Designs): Were the participants (e.g. students, schools) in the group receiving the intervention comparable to the participants in the comparison group?	0.0	0
Composite Question 3d. Clarity of Causal Inference: Fair Comparison (for Single-Factor Within-Subject Designs where two or more interventions are administered to a single sample of participants): Were the participants assigned to treatments in such a way that the effects of the intervention could be interpreted unambiguously?	1.6	7
Composite Question 3e. Clarity of Causal Inference: Fair Comparison (for Single Subject Designs, with baselines and one or more interventions, administered to the same sample of participants): Did the participants receive treatments in such a	1.7	3

[5] Ranks: 3-Yes, 2-Maybe Yes, 1-Maybe No, 0-No.

Study Design Elements (DIAD)	Mean Rank[5]	N
way that the effects of the intervention could be interpreted unambiguously?		
Composite Question 4. Clarity of Causal Inference: Was the study free of events that happened at the same time as the intervention that confused its effect?	2.3	20
Composite Question 5. Generality of Findings: Inclusive Sampling: Were targeted participants, settings, outcomes, and occasions included in the study?	2.6	20
Composite Question 6. Generality of Findings: Effects Tested Within Sub-Groups: Was the intervention tested for its effectiveness within important subgroups of target participants, settings, outcomes, occasions, and intervention variations?	1.7	20
Composite Question 7. Precision of Outcome: Effect Size Estimation: Were the effect sizes accurately estimated?	1.9	20
Composite Question 8a. Precision of Outcome: Statistical Reporting: Were the statistical tests adequately reported?	2.1	17
Composite Question 8b. Precision of Outcome: Statistical Description and Graphic Representation for Single Subject Designs: Were descriptions of the quantitative results and/or graphic representations adequately reported?	2.7	3