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A Review of Literature: Mathematics Instruction for Students with Visual Impairments

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Abstract

All students, including students with visual impairments (VI), are expected to master basic mathematics skills and apply such skills to solve real life problems. In the present study, we conducted a literature review of current intervention methodologies to assist students with VI to learn mathematics. A systematic review of literature yielded 5 studies, and all are single-case studies published after 2010s. Two trends in intervention methods emerged: (1) technological interventions, which used audio devices as aids for mathematics problem-solving and (2) human-delivered cognitive interventions, which focused creating specialized instruction for educators to better suit the needs of individuals with VI. The significance and limitations of current research and recommendations for future research are discussed.

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Introduction

Vision is one of the most important modes of learning we use to understand the world around us; however, not all are able to learn through vision. The World Health Organization reports that the estimated number of people who are visually impaired (VI) in the world is 285 million, where an estimated 19 million children below the age of 15 are visually impaired. These children with VI experience difficulties with academic and social activities at school such as inaccessibility to educational materials and limited social interaction.

Students with VI must be able to have proper education experience in order to be competitive in careers. Modern workplaces require increasingly advanced computational and technological skills. Hence, those who lack these skills are restricted in their career opportunities [1]. Science, technology, engineering and mathematics (STEM) fields are becoming increasingly important areas, and a solid basis in mathematics from an early age helps build logic and problem-solving skills. Knowledge in mathematics is essential to completing everyday tasks and children with VI should learn math skills at the same level as their sighted peers. Unfortunately, research shows that elementary and middle school students who are blind or visually impaired lag up to three years behind their normal-developing peers in mathematics achievement and that students with VI have lower math scores than their nondisabled peers (e.g., North Carolina State Board of Education, 2014) [2, 3].

Students with VI have the potential in mathematics achievement on par with their non-disabled peers if educated appropriately for their needs [4]. While no review to date has examined effective intervention practices for teaching mathematics to students with VI, instructional practices have incorporated interventions targeting mathematics. Hence, there is a need to determine appropriate educational methods to instruct students with VI in mathematics.

Research question(s)

The primary purpose of this review was to summarize and evaluate the effectiveness of existing methods to instruct students with VI to learn mathematics. We will also examine the quality of the existing research in order to provide suggestions for future directions in research on mathematics instruction for students with VI.

Method

Literature search procedures

Search procedures consisted of an electronic search and a hand-search. First, the electronic search was conducted by accessing databases including ERIC, EBSCOhost, Google Scholar, PsychInfo, and ProQuest. Descriptors for the electronic search included: mathematics, learning/education/teaching/instruction/, visual impairment/visually impaired/visually handicapped/blind/

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low vision, and program/intervention. Second, using the same descriptors of the electronic search, the hand-search was conducted by checking important journals including *Journal of Special Education*, *Remedial and Special Education*, *Exceptional Children*, *Journal of Visual Impairment & Blindness*, *Intervention in School & Clinic*, and *Exceptionality.*

Criteria for inclusion

Because we are interested in understanding mathematics education for individuals with VI, we created the following criteria for inclusion according to the recommendations by What Works Clearninghouse (WWC)(http://ies.ed.gov/ncee/wwc/topic.aspx?sid=9) to provide scientific evidence. To be included in the review, the article must have (a) focused on intervention methods, (b) focused on mathematics, (c) included participants with VI; (d) use an experimental, quasi-experimental, or single-subject design, and (e) published in peer-reviewed journals in English. Conference presentations, papers published in conference proceedings, or papers published in non-peer reviewed journals were excluded in this synthesis.

Search results

The electronic search yielded 273 results and four of the results met inclusionary criteria. The hand-search identified another article that met inclusionary criteria and was selected. Five studies were included in this review.

Results

Of the studies included in this review, two main intervention methods used to instruct student with VI in mathematics emerged: Assistive technologies and human-delivered cognitive interventions. All five studies are single-case studies in nature, reflecting the difficulties with recruiting participants with VI.

Assistive technology

Three studies were identified under the category of assistive technology [5-7]. All three studies provided audio material to help students with VI access information. However, none of the three studies could make a strong conclusion that assistive technologies providing audio information are more effective than traditional methods.

Beal, Rosenblum and Smith had fourteen students with VI, including 7 males and 7 females from grades 5 through grade 12, participate in the field-testing of AnimalWatch-VI-Beta, a computer program that delivered 12 prealgebra math problems and hints through a self-voicing audio feature [5]. Their grade equivalence in mathematics varied from 3+ years below grade level to above grade level. The computer program gave the students a series of word problems with which they must solve using the self-voicing audio feature. Auditory hints were available to students if needed. Results suggest that participants performed well on the easy and medium difficulty problems with over 90% correct, and got approximately 50% correct on hard problems. The authors claimed that the audio hints appeared especially helpful to students with VI who were below grade level in math. However, there was no baseline session and comparison of the computerized program with any other conditions. Therefore, one can not make a conclusion that the computerized program is effective to promote math learning for students with VI.

Bouck and Weng conducted an intervention to understand how the performance of three secondary students with visual impairments was impacted by accessing algebra via a digital textbook in comparison to accessing it via a traditional textbook [6]. Two versions of the traditional textbook were used: small print and braille. The digital textbook was presented via a supported eText software player called “ReadHear” which uses the output language of MathSpeak in this study. Bouck and Weng had 3 participants with VI in grades 9-12. With an alternating treatment design, the researchers alternated using of the digital textbook presented via ReadHear and the traditional textbook to the participants with VI. In the traditional textbook condition, one student read the small print with CCTV to enlarge the font, one student read in braille, and one student just read the small -print book. The dependent measure was students’ performance on math problems selected from the Algebra I textbook (Glencoe McGraw-Hill, 2008), including the points for questions answered correctly per assessment and the task completion time of each assessment [8]. Results showed that students solved the algebra equations better when presented via their traditional textbook, that their task completion was longer for all three students when using the digital textbook, and that two of the three participants preferred their traditional textbook while one preferred the digital textbook.

Bouck et al. (2011) compared the effects of a newly developed computer-based voice input, speech output (VISO) calculator with students’ regular method of calculation [7]. Their participants were three students with VI, including one male and two females with an age range of 18-19. The participants were asked to complete computational math problems with the VISO calculator and with their regular method of calculation where the participants used a talking calculator, or relying on another individual to input numbers into a calculator. The time they took to complete assessments and the average number of attempts per problem was recorded. Results suggest that when using the VISO calculator, students required more time to complete the assessments than with their typical method of calculation. Using the VISO calculator also required a higher number of attempts to enter problems than their typical method of calculation. With more experience of using the VISO calculator, the time of completion and attempts per problem both decreased though it still took more time and attempts than when using their typical calculation method. Researchers noted that the use of a free speech recognition system sometimes was unable to understand what the students were saying and thus may also have frustrated the participants. Although the VISO calculator seemed to bring in few advantages, the participants also noted the benefits of the VISO calculator such as independence and other positive perceptions of the calculator such as the potential to expand the calculator’s abilities to include graphing.

Human-delivered cognitive instruction

Two studies were identified using cognitive instruction via individualized instruction to each participant to assist the math learning of students with VI [9, 10].

Chang and Bin conducted an intervention that explored whether people who are blind and have no visual experience are able to learn how to draw perspective through education which is necessary to build an understanding in several fields of mathematics such as geometry [9]. A 25-years old male college student with VI participated in this study. The researcher used a cube as the stimulus, together with special teaching aids, to help a participant with congenital total blindness understand the drawing method used by his sighted counterparts to illustrate the three-dimensional object that is a cube which is typical in geometry instruction when diagraming volume problems. Results suggest that after completing the lessons, the participant was able to select the correct oblique projection of a cube and no longer insisted that a cube can only be ideally represented by a square, however, although he was able to cognitively accept the concept, he was unable to join various dimensions (such as joining various corners of the cube). The findings of the research suggest that appropriate graphic teaching at an early age would enhance the learning performance of representing perspective because a person who is blind would be familiar with the visual operations of a sighted person. However, the design with only one participant limited the generalizability of the results, and that the setting and duration of time was unreported.

Pevsner, Sanspree and Allison conducted an intervention that investigated the effects of teaching strategies that address individual learning styles for students with VI [10]. Quantitative data was obtained to determine individual learning preferences. The participants were 5 second to fourth graders, including two males and three females, with VI. Test scores on the Alabama Reading and Math Test (2002) were collected for the participants and compared to typical classmate scores. Qualitative interviews were also conducted to explore the students' attitudes concerning school. Results suggested that when learning styles were addressed, test scores of students remained the same or improved, and there was an increase of positive responses of students' attitudes towards school. However, when the test scores of the five participants with VI were compared to peers in the control group, the increase in test scores was not statistically significant- this may be due to the smaller sample size of students with VI and a group study with larger sample size is warranted.

Discussion

This review provides a systematic review of literature on existing interventions methods that assist students with VI to learn mathematics. Five studies were identified, including two studies focusing on human delivered cognitive interventions and three studies on assistive technologies. On one hand, despite the difficulties that VI creates for individuals with VI learning mathematics, it appears that there is not adequate research focused on this issue. On the other hand, all these five studies were conducted only within recent years (2011-2014), including an increasing attention to this important education topic [11-13].

In addition, due the single case studies in nature, one should be cautious to generalize the conclusions from these studies to a broader population with VI. In particular, some studies did not follow the rigor of single subject designs, for example, Beal, Beal, Rosenblum and Smith, did not include a baseline phase so one cannot claim that the participants made an improvement with the assistance of technology; the study by Chang & Bin only included one participant with a AB design, so no replication was demonstrated and no functional relation can be established with this design; Pevsner, Sanspree and Allison attempted to conduct inferential statistics with group comparisons but the sample size was too small to ensure the power; the alternating design used in two studies by Bouck could not establish a functional relation between the intervention and outcome measures. In sum, future research with more rigorous designs, especially randomized controlled trial experiments, are needed [5, 9, 10].

Due to the limited amount of available literature on the subject, we are unable to statistically compare which intervention method is more effective than the other; however, several implications have emerged from the literature in review that can aid mathematics educators of students with VI. First, from the three included studies, assistive technologies do not seem to be more effective than traditional instruction methods for students with VI in mathematics learning, which may reflect students' unfamiliar with technologies. Bouck, et al. noted that the length of time required to complete an assessment decreased the more the participants used the VISO calculator, and suggested that allowing students to have familiarity with any accessible technological aids may allow students to use these devices more quickly and it may even become a more efficient method of mathematics problem-solving over their typical method [7]. Second, human delivered cognitive instruction seems to be effective. Chang and Bin's study suggested that specialized mathematics instruction is effective for students with VI and Pevsner, Sanspree and Allison found that addressing students' individualized learning style can help maintain and create more positive attitudes towards school and mathematics learning [10]. Another limitation exists and needs to be addressed in future research. There are many types of vision loss, for examples, individually with congenital blindness and adventitious blindness can be very different. Unfortunately, the reviewed studies did not specifically compare the effectiveness of interventions among individuals with different types of vision loss. Further investigations are needed to improve teachers' instructional methods, particularly the differentiated interventions for students with varying vision loss categories.

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References

1 Kapperman G, Sticken J (2002) A software tutorial for learning the nemeth code of braille mathematics. J Vis Impair Blind 96: 855-57.

2 Blackorby J, Cameto R (2004) Changes in school engagement and academic performance of students with disabilities. In Wave 1 Wave 2 Overview (SEELS). Menlo Park, CA: SRI International, pp. 8-1-24.

3 Blackorby J, Chorost M, Garza N, Guzman AM (2005) The academic performance of elementary and middle school students with disabilities. In Holden-Pitt. L. (Ed.) Engagement,academics, social adjustment, and independence: The achievements of elementary and middle school students with disabilities. USA: U.S. Department of Education.

4 Kapperman G, Sticken J (2003) Practice Report: A case for increased training in the nemeth code of braille mathematics for teachers of students who are visually impaired. J Vis Impair Blind 97: 110-112.

5 Beal CR, Rosenblum LP, Smith DW (2011) A pilot study of a self-voicing computer program for prealgebra math problems. J Vis Impair Blind 105: 157.

6 Bouck EC, Weng PL (2014) Reading math: A comparison of reading and listening to algebraic problems. Journal of Special Education Technology 29: 1-13.

7 Bouck EC, Flanagan S, Joshi GS, Sheikh W, Schleppenbach, D (2011) Speaking math--a voice input, speech output calculator for students with visual impairments. Journal of Special Education Technology 26: 1-14.

8 Berchie H, et al. (2008) Algebra I. Columbus, OH: Glencoe McGraw-Hill.

9 Chang WC, Bin I (2013) The difficulties in teaching an adult with congenital blindness to draw cubes: A case study. J Vis Impair Blind 107: 144-149.

10 Pevsner D, Sanspree MJ, Allison C (2012) Teaching strategies for learning styles of students with visual impairments. Insight: Research & Practice in Visual Impairment & Blindness 5: 59-69.

11 Public Schools of North Carolina. N.p. (2013). Reports of Disaggregated State, School System (LEA) and School Performance Data for 2011 - 2013.

12 Tindell M (2006) Technology and Life Skills- A Beginner's Guide to Access Technology for Blind Students: Part Two. Future Reflections.

13 Visual Impairment and Blindness (2014) WHO.