

## CHAPTER TWO

### TEACHING MATHEMATICS TO STUDENTS WITH VISUAL IMPAIRMENT

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#### **Introduction**

The instruction of mathematics is emphasized in schools across America, and it is important that students who are visually impaired are not excluded from this national effort (Kapperman&Sticken, 2003). Although children who are visually impaired learn mathematical skills at the same level as their sighted peers (Tindell, 2006), the abstract nature of many essential concepts and the highly visual presentation of the subject can make the acquisition of mathematical skills more challenging for these students (Kapperman, Heinze, &Sticken, 2000). Based on a summary of literature, this discussion highlights the most effective methods for delivering mathematics instruction to students with visual impairments and provides implications for teacher implementation in the field.

The No Child Left Behind Act of 2001 (NCLB) established accountability measures, including annual assessment of students in the area of mathematics, as proficiency in mathematics is critical to functioning adequately in daily life situations (National Mathematics Advisory Panel, 2008). Mathematical problem solving is one of the most important concepts taught in the grade-level curriculum, and legislation and state testing requirements such as NCLB's state assessments (2001) focus on a conceptual understanding of mathematical concepts, skills, and relations of numbers (Jitendra, 2007). A thorough understanding of mathematics enhances educational and occupational opportunities for all people, as the workplace requires increasingly advanced computational and technological skills; those who do not possess these skills are restricted in career choices (Kapperman&Sticken, 2003).

However, students with visual impairments tend to face more challenges than their peers without disabilities, even when learning the most basic mathematical concepts (Beal & Shaw, 2008). These difficulties include problem solving, gaining access to the problem information, representing problem information, and calculating the answer. Additionally, mathematics is highly visual in nature and often uses graphics to convey important information, presenting an additional obstacle for students with visual impairments (Smith & Smothers, 2012).

Some challenges that students with visual impairments encounter when learning mathematics can be overcome when the content is taught in an appropriate manner, such as by using programmed instruction (Agrawal, 2004). Programmed instruction, which includes developing a sequence of instructional

activities, has the potential to maximize learning and increase motivation for students with visual impairments. It has also been established that children who are visually impaired should learn mathematical skills at the same level as their sighted peers (An opportunity to explore mathematics using different instructional tools in these early years is beneficial to this population of students as well (Amato, Hong, & Rosenblum, 2013). Finally, exposing students with visual impairments to experiences in individual environments promotes natural development of mathematics skills, which can lead to positive attitudes toward mathematics and build students' confidence level.

The thesis statement examines the methods of teaching students with visual impairment mathematics. The chapter discussed the traditional methods of teaching mathematics to students with visual impairment (SVI) which are Abacus, Braille codes, Geometric Tactile graphic kits, Neimeth code, tactile diagram and Taylor frame. Also, highlighted are the current methods of teaching mathematics which use new technologies like the screen reading software such as the Text-To-Speech (TTS), Non-Visual Desktop Access (NVDA), Job Access With Speech (JAWS). The chapter also examined some challenges faced by students with visual impairment (SVI). Finally, the implications of teaching mathematics to the students with SVI was stated.

### **Mathematics for Students with Visual Impairment**

Mathematics involves the study of number patterns and its relationships. In the inclusive era students with visual impairment are expecting to perform the calculations like their normal peers. Achievement in maths by students with visual impairment tends to be poor relative to performance in other academic subjects. Students face multiple challenges in mathematics problem solving, including gaining access to the problem information, mapping the problem information to the appropriate representation, and providing the resulting answer. Vision enables access to important information that supports students' development of mathematical concepts and procedures (Klingenberg, Holkesvik and Augustad, 2020). Mani, plernchaivanich, Ramesh and Campbell (2005) mentioned that the key factors considered important for effective learning of mathematics by students with visual impairment are as follows:

- Selection and teaching of suitable mathematical Braille codes.
- Adaptation of text material to children with visual impairment.
- Teaching mathematical devices
- Provision of right mathematics text material.
- Preparation and use of appropriate teaching aids.
- Provision of simulating experiences, creation of situational approaches, etc., The method of teaching mathematics to students with visual impairment should include using a combination of abacus, Braille codes, tactile materials, and concrete materials (Rosenblum and Smith, 2012). Students with visual impairments face problems when learning mathematics, these can be overcome when the content is

taught in an appropriate manner, such as by using programmed instruction. Programmed instruction is a sequence of instructional activities which increase motivation for students with visual impairments (Agrawal, 2004).

Bilal (2017) shared that mathematics is a very important subject to develop reasoning and decision-making skills. He conducted a qualitative inquiry study to explore students with visual impairment, personal, academic, and administrative problems in mathematics learning. The study found that they were facing diversified problems in learning of mathematics such as fatigue, lack of interest and motivation, behavior of teachers and administration, lack of skilled professional mathematics teachers, and lack of equipment and resources

### **Traditional Methods of Teaching Mathematics to Students with Visual Impairment**

In the current era of inclusivity, students with visual impairments receive the same education in all subjects as their peers. In Nigeria, teachers utilize various assistive devices such as; Abacus, Taylor Frame, Geometry Tactile Graphics Kit, Nemeth Code and Tactile Diagrams to teach mathematics to SVI.

**Taylor Frame:** Taylor's Frame is a mathematical teaching aid which provides a complete tactile solution for students with visual impairment to learn mathematics. By using this device, students can do arithmetic and algebra calculations independently.

**Tactile Diagrams:** Tactile diagrams are diagrams with embossed forms or with touch sense. It represents the visual information into a tactual sense. It allows students with visual impairment to get information about the concepts.

**Abacus:** The Cranmer abacus is one tool used to teach students with visual impairments to compute mathematical problems. The operations of addition and subtraction are the most frequently taught skills using the abacus. Setting and counting are also in the realm of mathematical skills taught using an abacus. Conversely, higher-level mathematical computation skills, such as multiplication with multiple digits and computing with fractions, are said to be taught less frequently using an abacus. In addition, Teachers of students with visual impairment (TVI) do not use the abacus for these higher order skills because of the increased use of technology to solve problems in higher grades, students' use of mental math, and the abacus not being deemed an appropriate tool for certain students.

Amato et al. (2013) report that students who have abacus skills included in their Individualized Education Program (IEP) seem to enjoy instruction and experience positive results when the classroom teacher is able to learn with the student.

**Nemeth Code:** Abraham Nemeth developed the Braille codes for mathematical notations and symbols in the year 1952. The Nemeth mathematical Braille code is useful for denoting mathematical and scientific notation. Students with visual impairment can read the calculations with the help of Nemeth code. The Nemeth

Code for braille mathematics and science notation is also an effective tool which gives students who are visually impaired access to mathematical work, and allows them to produce solutions to computations (Rosenblum & Smith, 2012). The Nemeth Code introduce principles and procedures for the presentation of braille equivalents for the complex signs and configurations of ink-print mathematical and scientific notation (Craig, 1987). This code is a living document and continues to be updated and refined to assure the correct transfer from ink print to braille.

As the United States transitions to Unified English Braille (UEB), TVI need to be proficient in both codes in order to be able to convert efficiently from one code to the other. Without knowledge of these codes, students who are visually impaired may not be able to participate actively with their peers in mathematics. When teaching mathematical concepts, TVI should ensure the student is presented with flawless braille and adhere to all of the mathematical code's rules (Kapperman et al., 2000). Considerable confusion can arise when changes to the written forms of the symbols are made, which means that the correct form should always be maintained. When providing instruction in advanced mathematics, TVI are not expected to know the meaning of each print symbol, but should consult with the general education teacher to ensure that the symbols have been correctly interpreted by the student who is blind. Overall, TVI need to feel confident in their ability to teach the Nemeth Code and UEB to verify that students are accessing all areas of mathematics and science properly.

**Geometric Tactile Graphics:** Tactile graphics, or “graphics intended to be read principally by touch rather than vision,” are also a beneficial tool for teaching mathematics to students with visual impairments (Aldrich, Sheppard, & Hindle, 2003, p. 284). Tactile graphics represent a variety of print illustrations that contain information given in graphic formats. They are just as important to the braille reader as print diagrams are to the sighted student (O'Day, 2014). Nonetheless, a major issue with tactile graphics that students with visual impairments must overcome is the amount of visual aspects in mathematics, specifically in geometry and data analysis (Smith and Smothers, 2012). Due to the inclusion of these highly visual concepts, it is important that tactile graphics are utilized to develop a thorough understanding in mathematics for students with visual impairments.

In addition to providing tactile graphics for their students, it is necessary that TVI teach students how to read and make sense of tactile graphics in mathematics instruction. In order to teach students with visual impairments to be successful in handling and interpreting a variety of tactile graphics, TVI should use a sequence for introduction of tactile graphics to first present to students with the opportunities to handle real objects, transition to the use of models, and finally implement two dimensional representations (Willings, 2019). The successful reading of tactile graphics requires knowledge of spatial and geographic concepts and strategies for exploring and interpreting the displays (Kapperman et al., 2000). The use of tactile graphics in mathematics for students with visual

impairments can assist the students in building a greater understanding of visual mathematical concepts that otherwise would be misunderstood.

**Concrete Materials:** Concrete materials, or manipulatives, are available in multiple forms. They are often defined as “physical objects that are used as teaching tools to engage students in the hands-on learning of mathematics. Manipulatives assist students in learning numerous mathematical concepts including: addition and subtraction, operations with integers, fraction equivalents, counting money, telling time, measurement, and place value (Mastropieri & Scruggs, 2010). Manipulatives also offer children with visual impairments concrete experiences to help them understand their environment and learn concepts parallel to sighted peers in the classroom setting (Saracho, 2012). Concrete manipulatives are one of the major tools used when teaching visually impaired students during initial instruction in mathematical calculations as well (Kapperman et al., 2000). Finally, concrete manipulatives increase computation accuracy and have been recommended when teaching students with visual impairments. Real objects can be used to sort, match, compare, group, take apart, put together, seriate, and count. When teaching various mathematical concepts, items that can be used to help students with visual impairments conceptualize what is being taught include: various geometric shapes of different sizes, textures, and colours; felt boards; symbol stickers; and base ten blocks. Through the use of concrete manipulatives, students can more easily remember what they did and explain concepts to solve the problem (Stein & Bovalino, 2001). The effective use of manipulatives assists students with connecting ideas and integrating their knowledge so they gain a deeper understanding of mathematical concepts

To develop conceptual understanding using concrete manipulatives, students with visual impairments should read a mathematical problem, write it, listen to it being read, tactually explore the problem through manipulatives, and if possible, move their body and/or manipulative through space (Osterhaus, 1996). It is essential to use concrete materials appropriately when teaching new concepts by allowing students to explore the manipulative initially, and then integrate it into the curriculum

### **New Trends in Teaching Mathematics to Students with Visual Impairment**

Mathematical education is currently undergoing significant changes with regard to teaching and learning because of the development of technology and digital-based learning. Assistive technology plays a vital role in the lives of persons with disabilities. It is helpful for inclusion of persons with disability to participate in society. The main purpose of assistive devices is to improve an individual's functioning and independence in education, employment and independent living. One among them is screen reading software, which converts text information into speech.

**Screen Reading Software:** A screen reader is a software application that enables students with visual impairment to use a computer to hear and listen to the

information present on the screen. A screen reader application that works with Text-To-Speech (TTS) engine to interpret on-screen information into speech. The common screen reading software used by students with visual impairment is the Non Visual Desktop Access (NVDA), Screen Access For All (SAFA), Job Access With Speech (JAWS), Supernova and Window-Eyes. NVDA and SAFA are the open source & free access software whereas JAWS, Supernova and Window Eyes are the commercial product. Students with visual impairments can use screen reading software to learn mathematics. It allows students with visual impairment to learn mathematics at their own pace and time (Beal & Shaw, 2008). At first the Maths Language application should be installed in the system/ computer. The screen reader software works with math language applications (Dheesa, 2022). The table below show the maths language applications that support mathematics concepts in the computer.

Math language application

s/no	Name of Math Language Application
1	MathML
2	MathTalk
3	MathJax
4	MathPlayer
5	MathX

Screen Reading Software in Learning Mathematics: Students with visual impairment can understand mathematical calculations like their peer groups with the help of screen reading software. It promotes

- Equal educational opportunity: By using screen reading software, students with visual impairment can learn and do mathematics independently which provides equity and equal educational opportunity to them.
- Better inclusion: It facilitates inclusion of students with visual impairment in mathematics classrooms.

### **Challenges of Teaching Mathematics to Students with Visual Impairment**

Inaccessibility to learning materials: Many mathematics textbooks have visual images with important content information that is not transcribed or described in either Braille books or digital versions of the texts. This trend is making textbooks, to become inaccessible to students with visual impairment (SVI), even more challenging for blind and partially sighted learners. Graphs, charts, diagrams, figures, and drawings are used as mathematical tools to communicate huge amount

of information or relationships between variables in a simplified and concise way. An important mathematical skill is to gather information from such graphics and use it to solve problems (Oyebanji and Ubong, 2021). However, curricular graphic materials are visual in nature and therefore many students with SVI face considerable challenges in reading them (Rosenblum & Herzberg, 2015).

Teacher's lack of competence in using the technologies: Some TVI lack the skills to teach students with visual impairments because they: (a) do not believe they are effective instructors in the use of mathematics technologies; they lack the confidence to teach SVI; they have not updated their skills through workshops or in-service trainings; they do not have sufficient time to teach students due to curricular demands. However, it is important to remember that a teacher's competence and attitude have a great impact on a student's potential for success.

### **Implications Teaching Mathematics to Students with Visual Impairment**

#### **Preamble**

1. Inclusion and equity : the knowledge of science and mathematics will promote inclusion and equity in education by providing equal access to mathematical content and enable the student to achieve their full potential and participate fully in their community
2. Students with visual impairment develop manipulative, reasoning, creative and problem solving skills which can be applied to solve problems in other areas of their life
3. The knowledge of mathematics and related subjects help to boost the confidence and self-concept of SVI
4. The knowledge of mathematics opens new doors for a wider career choice. The SVI can now pursue careers in other fields and areas of their interest

#### **Conclusion**

Students with visual impairments require a thorough understanding of mathematics to function in today's society. Students with visual impairment should learn mathematical concepts like their sighted peers in the classroom. It is beneficial for mathematics to be presented to students with visual impairments using a combination of the abacus, Braille codes, tactile materials, and concrete materials in order to meet academic goals (Brawand and Johnson, 2016). It is also important that every school should have all kinds of assistive devices including screen reading software to teach mathematics. Selecting and teaching with appropriatedevices, students with visual impairment can shine in performing mathematics calculations

#### **Suggestions**

The following suggestions are proffered;

1. Special education teachers should be trained and retrained on the use of new technologies to help them develop effective skills and strategies for teaching mathematics to SVI
2. Reading and writing equipment's such as braille machines, laptops and computers installed with mathematics languages application soft wear should be adequately supplied to schools to ease the challenges of learning mathematics by SVI
3. Students with visual impairment who show interest in the field of science and mathematics should be encouraged by specialist to pursue careers in such fields
4. Teachers should use multisensory teaching methods that involve touch, sound and movement. Example the use of tactile materials like braille, raised - line- drawings, and manipulatives or hands - on- activities

### References

- Agrawal, S. (2004). Teaching mathematics to blind students through programmed learning strategies. New Delhi, India: Abhijit Publication
- Aldrich, F., Sheppard, L., &Hindle, Y. (2003). First steps towards a model of tactile graphicacy. *The Cartographic Journal*, 40(3), 283-287. doi: 10.1179/000870403225013014
- Amato, S., Hong, S., & Rosenblum, P. (2013). The abacus: Instruction by teachers of students with visual impairments. *Journal of Visual Impairment and Blindness*, 107(4), 262-272.
- Bilal, A. (2017). Problems Faced By The Students With Visual Impairment In Learning Mathematics. DOI. 10.13140/RG.2.2.15653.24802.
- Brawand, A. & Johnson, N. (2016).Effective Methods for Delivering Mathematics Instruction to Students with Visual Impairments.*Journal of blindness innovation research. Vol 6(1)*
- Brawand, A., & Johnson, N. (2016).Effective methods for delivering mathematics instruction to students with visual impairments.*Journal of Blindness Innovation and Research.6 (1).*<https://nfb.org/images/nfb/publications/jbir/jbir16/jbir060101.html>.
- Craig, R. (1987). Learning the Nemeth braille code: A manual for teachers and students. Provo, UT: Brigham University Press.
- Dheesa, J. B. (2022). Teaching mathematics to students with visual impairment with screen reading software. *Researchgate.netpublication/36341219 Teaching\_Mathematics \_ to\_Students\_with\_Visual\_Impairment- Screen\_Reading\_Software*
- Kapperman, G., &Sticken, J. (2003).A case for increased training in the Nemeth code of braille mathematics for teachers of students who are visually impaired. *Journal of Visual Impairment and Blindness*, 97(2), 110.
- Kapperman, G., Heinze, T., &Sticken, J. (2000).Mathematics. In A.J. Koenig &M.C. Holbrook (Eds.), *Foundations of education: Instructional strategies for*

- teaching children and youths with visual impairments (Vol. II, pp. 370-399).  
New York: AFB Press.
- Klingenberg, O.G., Holkesvik, A.H., & Augestad, L.B. (2020). Digital learning in mathematics for students with severe visual impairment: A systematic review. *British Journal of Visual Impairment*, 38(1). <https://journals.sagepub.com/doi/10.1177/0264619619876975>.
- Mani, M.N.G., Plernchaivanich, A., Ramesh, G.R., & Campbell, L. (2005). *Mathematic Made Easy For Children With Visual Impairment*. <https://www.academia.edu/36688014/>.
- Mastropieri, M. A., & Scruggs, T.E. (2010). *The inclusive classroom: Strategies for effective differentiated instruction* (4th ed.). Upper Saddle River, NJ: Merrill.
- No Child Left Behind Act of 2001, Pub. L. No. 107-110, 115 Stat. 1425 (2002).
- O'Day, A. R. (2014). Proofreading the tactile graphic: The important last step. *Journal of Blindness Innovation and Research*, 4(1). <http://dx.doi.org/10.5241/4-59>
- Oyebanji, M. S. & Ubong, I. S. (2021). Challenges of teaching mathematics to students with visual impairment. *Malikussaleh journal of mathematics learning* vol 4 (1). ISSN 2620-6323 (online). DOI: <https://doi.org/10.29103/mjml.v4i1.2538>
- Rosenblum, P., & Smith, D. (2012). Instruction in specialized braille codes, abacus, and tactile graphics at universities in the United States and Canada. *Journal of Visual Impairment & Blindness*, 106(6), 339. <https://journals.sagepub.com/doi/pdf/10.1177/0145482X1210600603>.
- Rosenblum, P., Hong, S., & Amato, S. (2013). The abacus: Teachers' preparation and beliefs about their abacus preservice preparation. *Journal of Visual Impairment and Blindness*, 107(4), 274-285.
- Saracho, O. (2012). *An intergrated play-based curriculum for young children*. New York, NY: Routledge.
- Smith, D. W., & Smothers, S. M. (2012). The role and characteristics of tactile graphics in secondary mathematics and science textbooks in braille. *Journal of Visual Impairment and Blindness*, 106(9), 543.
- Stein, M. K., & Bovalino, J.W. (2001). Reflections on practice: Manipulatives: One piece of the puzzle. *Mathematics Teaching in Middle School*, 6(6), 356-359.
- The Rights of Persons with Disabilities Act (2016). [https://legislative.gov.in/sites/default/files/A2016-49\\_1.pdf](https://legislative.gov.in/sites/default/files/A2016-49_1.pdf).