

ENHANCING UNDERSTANDING OF VISUALLY IMPAIRED STUDENTS IN MATHEMATICS USING MANIPULATIVE MATERIALS

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Abstract

Manipulative materials are generally regarded as valuable tools of mathematics that provide experiential learning through concrete objects. The importance of the application of manipulative materials in imparting knowledge is supported by Piaget, Bruner and Skemp who stated that the development of mathematical concepts develop through physical objects into the form of representation and abstract thought. Student's mental image and abstract ideas are based on their experience. Therefore, students who see and manipulate various objects have a clearer mental image and can represent abstract ideas. Accordingly, this study aimed to explore the perceptions of teachers regarding the use of manipulative materials in helping to increase the understanding of Visually Impaired Students in the teaching and learning process of mathematics.

Qualitative research approach was utilized using structured interview method involving 10 teachers of mathematics in two special education primary schools for the visually impaired in Malaysia. The study reveals that there are four main manipulative materials used in teaching Mathematics specifically for Visually Impaired Students. Manipulative materials include embossed diagrams, Braille and normal print worksheets, concrete materials, tangible or natural materials, and special equipment. Math teachers who participated in this study showed great interest in using manipulative materials. Based on the experience of teachers, it was found that manipulative materials can help improve understanding of Visually Impaired Students in mathematics teaching and learning process. Therefore, the use of manipulative materials as a medium of instruction should be given priority in order to increase understanding of Visually Impaired Students, specifically towards mathematics at the primary school level.

Keywords: Visually Impaired Students, Mathematical Understanding, Manipulative Materials

Introduction

Mathematics is a subject that is important not only to education practitioners; it is indeed also important to everyone. Learning of mathematics starts from the early stages of schooling to the highest level in universities. The level and difficulty of mathematics change according to the level of mathematics learning in the education system. Proficiency in mathematics is a necessity to compete in placing oneself in various fields of professional career (Alajarmeh, Pontelli, & Son 2011; NCTM 2010). However, Kapperman and Sticken (2010) describe that mathematical notation depends entirely on visual discipline which is a major problem for students with visual impairment. In fact, mathematics is a field of knowledge that is complex at all basic, intermediate and advanced levels. Mathematical difficulties include how it is represented and encoded. Mathematics is not only difficult to learn for visually impaired students; it is also difficult for typical students because mathematics is a knowledge discipline that greatly requires accuracy, precision, and comprehensive understanding. Kapperman, Heinze and Sticken (2010) add that visually impaired students cannot see information in its totality like typical students; they need to combine a number of information to create the overall conclusion. Thus, mathematics is a difficult subject for students with visual impairment.

There are several terms commonly used for the visually impaired group; among them are visual impairment, blindness or functional blindness, legal blindness, low vision and functional vision. According to Huebner (2000), "*Visual impairment is a universal term that describes individuals with a decrease in visual functioning, regardless of the severity of their vision loss*". Meanwhile, Levack (1994) defined vision problems as "*identified organic differences in the visual system which are so severe that even after medical and conventional optical intervention, the student is unable to receive an appropriate education within the regular educational setting without special education services*" (p. 234). Blindness or functional blindness refers to individuals who "*use tactual and auditory senses as their primary avenues for gathering information*" (Hatlen 1996, p. 15). Legal blindness refers to individuals with "*acuity of 20/200 or less in the better eye with best possible correction or a field of 20° or less diameter in the better eye*" (Levack 1994, p. 229).

Low vision refers to students with "*reduced visual acuities or limited visual fields that inhibit the optimal processing of information through the visual modality and generally requires modifications or specialized materials to enable them to benefit from the educational process*" (Huebner 2000, p. 60). It has also been defined as "*having a significant visual impairment but also having some usable vision*" (Levack 1994, p. 230). Functional vision is defined as "*the ability to use vision in planning and performing a task*" (Holbrook and Koenig 2000, p. 315). In Malaysia, students with visual impairment according to the Rules of Education 2013 (Special Education) are defined as students who are certified by medical practitioners and opticians as students who have visual disability. Based on the various definitions above, it can be concluded that students with visual impairment refer to students who have significant disability or incapacity in their sense of sight even though the students have used corrective lenses (Gargiulo 2008; Huebner 2000; Hatlen 1996; Holbrook & Koenig 2000; Levack 1994).

Madungwe (2013) argues that in the process of teaching and learning mathematics, preparation of teaching aids should be accompanied by different media or in modified

forms so that students can learn through other senses apart from sight. The diversity of materials recommended should be adjusted to the general approach used by the teachers in teaching students with visual impairment, including through the representation of touch, audio aid, 3-D representation of the material, haptic devices, and integrated approach. In addition, Ferrell (2006) suggested the use of concrete materials in mathematics teaching to improve students' accuracy of calculation. Therefore, the use of manipulative materials is an important medium in the process of delivering mathematical knowledge more effectively.

Manipulative materials are widely used as an important tool in the teaching and learning of mathematics because they provide experiential learning through concrete objects (Burns & Hamm 2011). The importance of the application of manipulative materials in imparting knowledge is supported by the cognitive theory of Piaget (1952), Bruner (1966) and Skemp (1987) which states that the development of mathematical concepts develop through physical object into the form of representation and abstract thought. Students' mental image and abstract ideas are based on their experience. Therefore, students who see and manipulate various objects have a clearer mental image and can represent abstract ideas. In fact, according to Sowell (1989) in Burns and Hamm (2011), students who use manipulative materials for a long and continuous period of time surpass the basic level early compared to students who do not use manipulative materials. Sowell in a study which involved students who were weak in math had divided the students into two groups, namely 26 students who used concrete manipulatives and 24 students who used pictorial representation as the control group. The results showed that both groups showed an overall improvement in their understanding of fraction equivalence in the pre-test to post-test with the students in the concrete manipulative group showing overall mean score that is higher compared to the control group.

This view corresponds with Burns and Hamm's (2011) report which states that other studies have focused more on the relationship of students' achievement level with experience in using manipulatives. Raphael and Wahlstrom's (1989) study in Burns and Hamm (2011) found that the use of manipulatives in teachers' teaching play an important role as a medium of instruction and cover more curriculum content. In fact, the use of manipulative materials were found to contribute to better student achievement, especially in topics such as geometry, ratios, rates, percentages and fractions. Therefore, this study aimed to look at the types of manipulative materials suitable to be used and their importance in the process of teaching mathematics for visually impaired students based on the teacher's perspective.

Methodology

Research Objectives

This research aimed to explore teacher's perspective about the use of manipulative materials in helping to enhance understanding of visually impaired students in the teaching and learning process of mathematics.

- (a) Identifying the types of manipulative materials suitable to be used in the teaching and learning of mathematics especially for visually impaired students.
- (b) Exploring teacher's perspective on the importance of the use of manipulative materials in teaching and learning.

Research sample and location

A total of 10 teachers of mathematics were selected as respondents through purposive sampling method. The research location involved two special education primary schools in Malaysia.

Method of data collection and analysis

This study employed qualitative approach. The instrument of structured interview was used to explore teachers' views on the use of manipulative materials in mathematics to enhance understanding of visually impaired students. This method was chosen because it helps to get information about a phenomenon being studied (Noraini 2010). Selection of respondents in the study was based on purposive sampling. According to Noraini, purposive sampling involves the consideration of the individual to select a sample, based on the knowledge of the researcher and the specific purpose of the research. Selection of teachers' characteristics which are almost the same will enhance the validity and reliability of the qualitative research instrument (Merriam 1998). In addition, Merriam stresses that the validity of the interview data is also performed by showing the interview transcripts to the study's participants to be reviewed, and corrected, in terms of whether the transcripts accurately recorded the perspective of the study participants or otherwise. ATLAS.ti software was used in the data analysis process.

Research Findings

The research's findings indicated that the math teachers who took part in this research showed huge interest in using the manipulative materials. Detailed description of the findings based on the research objectives are as follows:

Types of manipulative materials suitable for use in the teaching and learning process of visually impaired students.

Based on the interviews with 10 special education teachers in two special education primary schools in Malaysia, it was found that there are four types of manipulative materials commonly used in math teaching and learning specifically for visually impaired students. First is the use of embossed diagrams. Embossed diagrams are modifications of diagrams or photographs into diagrams and images that have embossed or raised texture that can be sensed or felt with the fingers. This is recognized by respondent GPK FH (2014, 5:14) who stated, "*...aids that I usually use for example are embossed diagrams that are suitable for blind students*". Embossed diagrams are necessary to help teachers explain the transition from the real or concrete material in the form of 3D to the abstract condition in the form of 2D.

The second manipulative material is the braille and normal print or print worksheets. According to respondent GPK EIDA (2014, 4: 4), "*...for students who are blind, we are in great need of notes*". Therefore, GPK TA (2014, 9: 4) explained, "*...for those who have low vision, they still have partial sight left, so in terms of the approach it is almost similar to mainstream schools, but we have to modify in terms of the writing font for the students or we have to provide "large print"; for the blind as we already know, we certainly need braille*". Therefore, braille and large print sheets are necessary reading and reference materials in the teaching and learning process of visually impaired students.

Third are the concrete, tangible or natural materials. According to GPK MA (2014, 6:21), *"I prefer to use congkak and marbles for counting addition, subtraction, multiplication and division. Everyone can use the holes of the congkak. It is easier for pupils to understand"*. GPK MA (2014) employs actual tools commonly used by pupils in the game. The use of concrete or tangible materials that are commonly used in pupils' daily life make it easier for them to understand math concepts without having to take a long time to understand and get to know the materials used. This opinion is similar to GPK WMS (2014, 10:30) who stated, *"...When we carry out teaching for these visually impaired students, the priority is on teaching aids which are in concrete form"*. In addition to concrete or tangible materials that are used in the daily life of pupils, teachers also introduce or use new materials according to the suitability of topics taught, as GPK NAA (2014, 8:38) asserted, *"I do use ordinary materials, concrete materials that pupils commonly use; there are also new ones"*.

Fourth is the used of special equipment. There are some special equipment supplied by the ministry of education and there are also those purchased by the teachers themselves using financial allocations provided by the school. Among the special equipment used are such as braille machines, CCTV, thermoform, and embosser to facilitate teachers to prepare and use the materials directly during the teaching and learning process. GPK AIS (2014, 3: 5) explained, *"...this teaching and learning requirement for me what is important is for pupils who are totally blind or partially blind must have Braille machine and craft papers for typing or writing worksheets. Then for low vision pupils there must be CCTV or worksheets in the form of large print, enlarge the font size and also another requirement for teachers to teach mathematics is the need for thermoform and embosser, the thermoform to produce embossed diagrams"*. Based on the teachers' interviews, it was discovered that the required manipulative materials and equipment in the teaching and learning process for visually impaired students are different from the materials and equipment used by typical students in the mainstream classes.

The importance of the use of manipulative materials in mathematics teaching and learning from the teacher's perspective.

There are four benefits and significance of the use of manipulative materials as described by the teachers in the interviews conducted. First, manipulative is a form of modification of teaching materials from text form into concrete or tangible form that can be touched by the pupils with visual impairment. GPK NAA (2014, 1:59) stated, *"...there are students in the class who have low vision and there are those who are blind. We need modifications into embossed diagrams"*. Second, GPK MKA (2014, 7: 12-15) explained the importance of manipulatives based on student category, namely *"...B1 pupils require a complete range of concrete materials. Likewise, the equipment to produce embossed diagrams when I want to present about a concept to the students. For B2 pupils, concrete tools are very important to them such as magnifying glass with appropriate lighting. Printed materials also require suitable color and size. Next B3 pupils require print size that can help them get the right distance to see and read."* Manipulative materials are important to facilitate teachers in presenting learning concepts, and providing alternatives to pupils in terms of the use of materials other than textbooks, such as worksheets according to the suitability of the size of writing, lighting, and the distance required by visually impaired students to see and read.

In addition, GPK AAS (2014, 2:33) also added the third importance of manipulatives is as a tool or material that provides initial experience for pupils. Pupils learn from concrete materials before moving on to the abstract; the experience gained in school will be used in their daily lives. GPK AAS (2014) explained, "*I think concrete things are more suitable because after school they will use the existing experience*". This statement is similar to GPK EIDA (2014, 4:33) who agrees that, "*...indeed concrete materials are necessary and are associated with their existing experience*".

Fourth, manipulative materials help pupils understand more clearly. GPK EIDA (2014, 4:20) mentioned, "*...the use of concrete objects, objects that can hasten them to understand even if it is a single cup, I would definitely use. This means that the approach requires any material that can generate clear understanding*". This opinion is supported by GPK NAA (2014, 8:42) who stated that manipulative materials are important in presenting concepts in the early stages of teaching because they are more easily understood by the pupils, "*I will use all the concrete objects or real tools such as those commonly used by the pupils in their daily lives. These concrete materials are especially useful during the introduction; pupils must know the materials first and only then it is easy for us to explain and make them understand*". The teachers' statements clearly demonstrate that the use of manipulative materials in teaching and learning of mathematics has a positive impact on the understanding of visually impaired students.

Discussion

The use of manipulative materials in mathematics is often referred to as the bridge that connects concrete knowledge to the abstract (Heddens 1986). Based on the research objectives, the discussion is focused on the types of manipulative materials and their importance in enhancing visually impaired students' understanding.

Suitable types of manipulative materials.

Manipulative materials can exist in various forms of physical or concrete things that are used as a teaching tool to engage pupils in practical learning of mathematics. Educational research shows that the most effective learning occurs when pupils are actively involved in constructing their own mathematical understanding through the use of manipulative materials (Seefeldt & Wasik, 2006). Manipulative materials can be purchased at the store, brought from home, or produced by teachers and pupils themselves. Manipulative materials are used as a medium to facilitate teachers in presenting concepts and expedite pupils in understanding the topics taught. According to Smith (2009), manipulative materials used must be suited to the pupils' level of development, appropriate to the learning objectives and be used in the right way. Pupils need to understand the mathematical concepts taught and not just understand the manipulative materials used. Seefeldt and Wasik (2006) explain that the difficulty of preparing manipulative materials will increase because the pupils' thinking and understanding of mathematics will also increase. Seefeldt and Wasik also think that teachers should give pupils the opportunity to familiarize themselves with the manipulative materials to be used without having to set specific learning objectives before starting the teaching and learning. The opportunity for pupils to interact with the materials or tools will enable them to explore a variety of questions and generate various answers. This experience helps pupils to think about their world in an alternative way and helps them understand that there are different ways to solve problems.

Manipulative materials can be used in teaching of various mathematical topics including the four main areas of study as prescribed in the Primary School Standard Curriculum which are numbers and operations, measurement and geometry, association and algebra, and statistics and probability. In fact, manipulative materials can be used as a tool to communicate, to reason, make associations, solve problems, and make representation (Curriculum Development Division, 2013). Mathematics is often used to represent the world in which we live. Therefore, similarity between aspects of the world that are represented and aspects of the world that represent must exist. The abstract relationship between these two worlds can be described as shown in Figure 1 below:

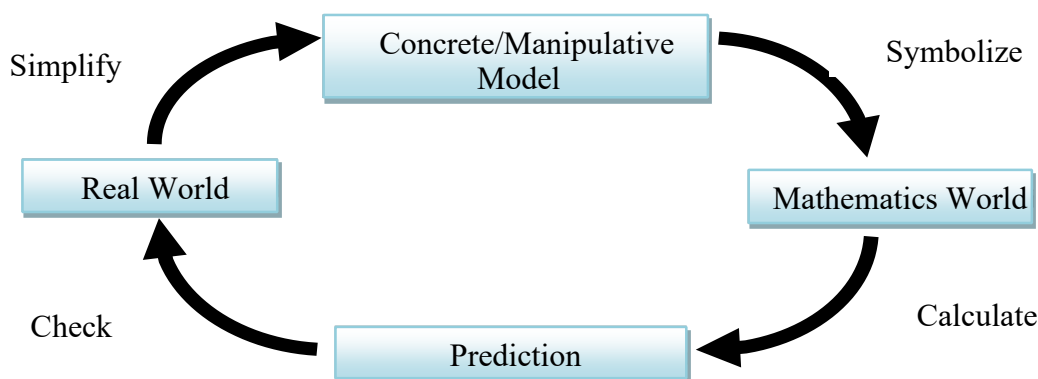


Figure 1 - The role of the Concrete/manipulative material model as a real world representation in mathematics, adapted from the Mathematics Year 4 KSSR Standard Document, Ministry of Education Malaysia (Curriculum Development Division 2013)

Figure 1 clearly shows that all manipulative materials that can represent real-world conditions are suitable to be used as a tool or medium that will facilitate the presentation of mathematical concepts to pupils. Based on previous research, it was found that the effectiveness of the use of manipulatives in teaching mathematics depends on the teacher's role in the structuring of when and how the manipulative materials are used to support learning. Pedagogical content knowledge of teachers and in-depth knowledge of a particular concept can help in customizing or adapting the manipulative materials to the learning objectives appropriate to the pupils' characteristics (Ma 1999; Shulman, 1986, 1987). Thus, manipulative tools or materials are not tied to only one type of material; in fact, it can cover all things considered by the teacher as appropriate with the ability of the visually impaired students who use hearing and touch as their primary sensors of learning.

Importance of manipulative materials.

Marshal and Paul (2008) assert that manipulatives are certainly good and help teaching becomes more effective. Marshal and Paul in their study found that teachers believe the use of manipulative materials enhances student learning. The effective use of manipulative materials can help students integrate their ideas and knowledge and gain a deep understanding of mathematical concepts. Over the past few decades, researchers have been studying the use of manipulatives in several grade levels and in different countries. Most of the studies show that achievement in mathematics increased when manipulative materials are used properly. In fact, Cain-Caston's study (1996) showed that

the use of manipulative materials help improve the learning environment in the mathematics classroom. When students learn using manipulative materials and explore the experience of using it, it not only enhanced the learning of mathematics, but also reduced anxiety towards mathematics. Chang (2008) studied the works of Jennifer Kaminski (a scientist) and found that children better understand math when they use concrete examples.

Kelly (2006) emphasized that teachers need to know when, why, and how to use manipulative materials effectively in the classroom. A study that describes the benefits of manipulative materials was conducted by Munger in 2007. Munger (2007) in Boggan, Harper and Whitmire (2010) carried out an experiment on a group of pupils using manipulative materials for the topic of geometry, while the other group only uses drawings of diagrams. Analysis of covariance revealed that the experimental group which used manipulative materials showed higher achievement scores in mathematics in the post-score compared to the control group that used only drawings. Boggan, Harper and Whitmire's (2010) study also showed that pupils who used manipulative materials in mathematics are more likely to succeed compared to those who are not exposed to manipulative materials during learning. Most students should be using manipulative materials to learn counting and pupils' understanding was found to increase with the use of manipulative materials.

Conclusion

Being involved in the teaching and learning of visually impaired students is a challenging field. Teachers need to be more creative in developing teaching and learning plans and finding materials and resources suitable to the needs and disabilities of students. Teaching and learning techniques and strategies for visually impaired students may be similar to a typical student, but would require a little bit of modification to make the process of delivering the mathematics knowledge more effective and meaningful for the students with visual impairment. This study reveals that teachers' selection on the use of concrete manipulative materials is more dominant at the primary school level. Math teachers use manipulative materials such as embossed or raised diagrams, braille and normal print worksheets, concrete materials, tangible or natural materials, and special equipment. There are also teachers who use virtual manipulative materials, but its use is only limited to low vision/ partially sighted students of normal cognitive level. The majority of teachers interviewed prefer concrete manipulative materials as a medium of teaching and learning at the primary school level in Malaysia.

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