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Increasing of the Blind Students' Mathematical Imagination through Inquiry-Based Learning Assisted with Manipulative Props

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Abstract

Mathematical imagination is needed by students with special needs, specially the blind students in learning mathematics. This can be done through Inquiry-based learning model assisted with manipulative props. This study aims to find out whether the blind students' mathematical imagination in inquiry-based learning assisted with manipulative props increases; describe the benefit of manipulative props in increasing the blind students' mathematical imagination, using inquiry-based learning. This research is a mixed methods research namely quantitative and qualitative approach. The Research Subjects was the blind student in class VII of academic year 2018/2019 of State Extraordinary School of Salatiga. The data take from mathematical imagination test, observation, interview, and document assessment. Based on the data analysis, the results show that the blind students' mathematical imagination increased after the implementation of inquiry-based learning assisted with manipulative props. Manipulative props with inquiry-based learning increased the blind students' mathematical imagination of circle circumference and area materials with Good Category, marked with all indicators and good category of mathematical imagination's sub indicators, good category of creativity of mathematical imagination, and good category of productivity in mathematical imagination. In learning at this school, it was important to teachers to implement this inquiry-based learning with manipulative props.

Keywords: Inquiry Based Learning, Manipulative Props, Mathematical Imagination, The Blind.

1. Introduction

Concerning Persons with Disabilities is stated that persons with disabilities are those who have physical, intellectual, mental, and/or sensory limitations for long periods of time in interacting with the environment can experience obstacles and difficulties to fully and effectively participate with other citizens based on equal rights (Republic of Indonesia, 2016). Persons with disabilities included the blind persons have the right to get quality education on education units in all types, lines and levels of education inclusively and in special manner. This is also confirmed by, Caiman & Lundegård (2018) that Citizen with physical, emotional, mental, intellectual, and/or social disabilities are entitled

to special education. Education services for persons with disabilities are provided throught Inclusive Education, Special School or Ordinary School.

The Children with Disabilities (CwD) included the blind children certainly becomes a major obstacle in interaction and receiving message include receiving materials at school. One of CwD is the blind. The blind students have a sense of sight interference which causes their mobility disrupted, it means that they have difficulties for moving from one to another place. The blind students visually lose information, but they maximize the functions of the other senses such as touch, smell, and hearing. The mobility inhibition makes the blind students tends to have high imagination than the other students. The blind students' mathematical imagination is the basis for increasing creative thinking and driving forces of innovation, so that the blind students will be able to face and find solutions for any problems they have.

Based on the explanation above, it is necessary to have an innovative learning process that makes the blind students being active in the learning process so that the material from the teacher is conveyed to the blind students, and they are able to find the concepts and solve the problems by themselves. Learning principles for the blind student are real principle, unified experience principle, and learning by doing principle (Hudson, Zambone, & Brickhouse, 2015). The purpose of real principle is learning for the blind student can be acceptable, experienced for real, and avoid the verbalism or concept that learned by only verbal. Real principle in accordance eith the contextual teaching and learning context that emphasizes direct experience in learning procees. Unified experience principle which means whole and complete, teacher in teaching must be giving whole experience, don't giving examples incompletely. This principles needed for blind students. Teacher in teaching new concept need props to avoid verbalism. Learning by doing principle related with real principle. This principle gives understanding that real experience giving to the blind students through learning by doing something is real experience that can be forgotten. Learning by doing give understanding and real experience in the learning procees. The principle that must be considered in teaching the blind students is that the media used has to be factual and voiced, for example the use of braille writing, embossed drawings, model objects, and real objects. While the voiced media can be tape recorders and JAWS software. JAWS is a screen reader application that has function to help the blind disabilities in operate computer.

Certain Learning Model also able to become a learning activity that can influences the increase of the blind students mathematical imagination. Due to the importance of the blind students' mathematical imagination, the learning model used has to be appropriate. The selection of the appropriate learning model is hope can increase the blind students' creativity and motivate them to be more enthusiastic in learning, so that it can increase students' learning outcomes related to mathematical imagination. One of the learning models that is hope can increase the blind students' learning outcomes is inquiry-based learning. Inquiry based-learning is learning model that emphasize the students role in learning procees (Ramey et al., 2016). The inquiry-based learning model is a learning model built based on the questions posed by students. This model is one of the learning models that use students learning center prinsiple. This model don't use "teacher telling the students" but the students pushed to

search more about materials, posed question, and more ideas. The inquiry-based learning model trains the blind students to be able to solve problems, so they are not just waiting for instructions from the teacher. In the inquiry-based learning model, the teacher's duty in the learning process is not to provide knowledge but to help students finding the knowledge by themselves. Inquiry learning model for the blind studends has characteristic, namely: (1) Inquiry learning model emphasize to the blind students activity to search and find materials by themselves, (2) All activities by the blind students directed to search and find answer for something questionable so the blind students can grow their self-confidence. (3) The purpose of inquiry learning model is to develop thinking ability in systematic, logic, and critical, or develop intelectual ability as a part of mental procees (Adebisi, Liman, & Longpoe, 2015). Critical thinking and creative thinking are two important competencies are needed in the 21st century (Toheri, Winarso, & Haqq, 2020).

The researcher choose inquiry-based learning model because this model makes student centered active learning concept more stronger or this learning centered on activity of the blind students. So, inquiry-based learning model invite the blind students in learning procees. The the blind students not only listening and writing in Braille all the materials but also the students have a chance to explore more idea in learning from their real experience. So that, the active student can find their concept from some material in learning process.

The physical limitations of the blind students make them difficult to receive the material, such as abstract objects. Therefore props that can change abstract objects into concrete objects are needed. Based on the initial observation results in the class, teacher has not used a props for explain the material in this research. Although props is very important in the learning process of the blind students. In this study, the researcher used a manipulative props.

Manipulative mathematical teaching props has function to help the blind students in understanding abstact mathematical concept. Manipulative props can be made in variety of forms and it is often defined as physical objects that is used as teaching tools to engage the blind students in the effective learning of mathematics, (Klingenberg, Holkesvik, Augestad, & Erdem, 2019). Manipulative props very helpful in mathematics learning which is abstract and full symbols. Manipulative props able to facilitate the blind students learning of math concepts by emphasizing the connection between concrete objects and math symbolization. Confirmed by research results of, Rosenblum, Hong, & Amato (2013) which shows that 83,3% respondents believe that manipulative props can be effective helps the blind students to understand mathematical concepts. There are 50% respondents believe that all students, regardless of their level of comprehension ability, requires manipulative assisted learning. However, only 20,8% think that all mathematics material can be taught through a manipulative props, (Lersilp, 2016).

Using manipulative props and productive questions in mathematics learning help teacher in giving stimulus for their students to find concept or principle, (Hidayah & Sugiarto, 2014). Props is one of teaching component that help effectivity of learning. Manipulative props change the subject materials from abstract to concrete and realistic. Learning with a manipulative props has meaning to optimize the function of all the four senses to increase the effectivity of the blind students learning

with listening, fingering, and use all their mind with logic and realistic, (Widiyatmoko, 2013). One of the benefit of the manipulative teaching props in learning mathematics is to lay down basic ideas on concepts. With the help of appropriate teaching props, the blind students can understand the basic ideas underlying a concept, know how to prove a formula or theorem, and can draw conclusions from the results of their observations, (Akakandelwa & Munsanje, 2012). In addition, teaching using manipulative props can increase students' attention in learning, because they are actively involved in learning. With the help of the manipulative props, the concentration of learning can be further improved. Manipulative props can also help the blind students to think logically and systematically, so they have the mindset needed to learn mathematics, (Akakandelwa & Munsanje, 2012). The use of manipulative teaching props supports the explanation of mathematical concepts. The use of manipulative props can help the blind students in the learning process because there is a concrete material presented by the teacher. However, it is need to pay attentioned to the use of manipulative props for the blind students such as in the subject material of circle so that the use of these props is maximized.

Furthermore, **Liang, Chang, & Hsu (2013)** suggested that mathematical imagination as one of "higher mental functions" which "involves synthetically combining memories or mathematical experiences aspects into different mental constructs from the past or present perceived reality and much anticipates the reality of the future. Mathematical imagination means students' imagination in acquiring experience in the learning process if he/she has difficulties in solving a problem, creative or alternative ways that students find to solve the problem. The indicators of mathematical imagination in this research consists of several aspects and indicators according to, **Mun, Mun, & Kim, (2015**) as follows: (1). Emotional understanding (EU), (2). The experience of imagination (EI), (3). Diversity (D), (4). Originality (O), (5) Creation and reproduction (CR), and (6). Scientific sense of reality (SSR).

Table1. Mathematical Imagination Indicators

Aspects	Indicators
Scientific Sensitivity (SS)	(1) Emotional understanding (EU) (2) The experience of imagination (EI)
Scientific Creativity (SC)	(3) Diversity (D) (4) Originality (O)
Scientific Productivity (SP)	(5) Creation and reproduction (CR) (6) Scientific sense of reality (SSR)

Imagination not only description of thinking ability, but also thinking for develop theirself **(Wibowo, Sutawidjaja, As' ari, & Sulandra, 2017)**. Imagination is important to students, especially the blind students. With mathematical imagination, the blind students can describe of abstract elements as concrete elements.

Indicators that show an increase in the mathematical imagination of the blind students are indicated by the fulfillment of indicators in the following aspects. (1) Aspect of Scientific Sensitivity (SS), (2) Aspect of Scientific Creativity (SC), and (3) Aspect of Scientific Productivity (SP).

The aspect of Scientific Creativity (SC) is marked by two indicators, namely the emergence of the Diversity (D) indicator, where students are able to come up with ideas to answer its questions. Then the Originality (O) indicator will appear, namely students are able to work alone in solving it.

The imagination process of Scientific Productivity (SP) is characterized by the emergence of two indicators of Creation and reproduction (CR) where students are able to come up with the correct steps to solve the problem. Next, the Scientific sense of reality (SSR) indicator will appear, where students are able to provide answers according to their questions.

Based on the indicators in Table 1 above, the categories for the growth the blind students' mathematical imagination are as follows.

Table2. Advanced Mathematical Thinking (AMT) Rubric Based on Teacher

Memenuhi Indikator	Kategori Mathematical Imagination of the Blind Students
(1), (2), (3), (4), (5), and (6)	Very Good
(1), (2), (3), (4), and (5)	Good
(1), (2), (3), and (4).	Medium
(1), (2), and (4).	Less
(1) and (4).	Very Less
(1), (2), (3), (4), (5), and (6)	Very Good

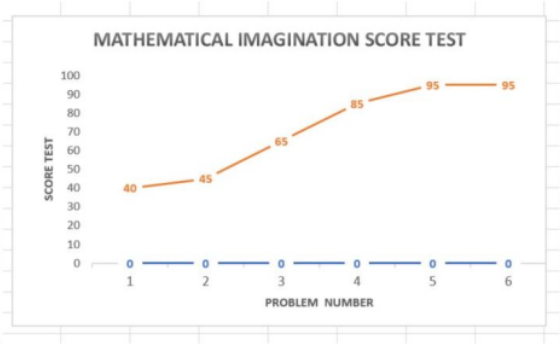

Figure1. The Graph of Mathematical Imagination Score Test

2. Objectives Of The Study

This study aims to: (1) Find out whether the blind students' mathematical imagination in inquiry-based learning assisted with manipulative props increases; (2) Describe the role of manipulative props in increasing the blind students' mathematical imagination of circle circumference and area materials through inquiry-based learning.

3. Method

3.1. Research Design

The research design used in this study is a mixed method that combines a quantitative approach and a qualitative approach. Quantitative analysis is used to determine the increase in student learning outcomes with visual impairment after the implementation of learning by utilizing manipulative teaching aids through the application of inquiry based learning learning models to blind students. on the circumference and area of the circle subject matter. While qualitative analysis is used to describe the growth of blind students' mathematical imagination in working on questions after students are given learning by utilizing manipulative teaching aids through the application of the inquiry based learning model.

3.2. Data Collection, Research Subjects, and Data Analysis

This research method is carried out through mixed methods, which combines quantitative and qualitative approaches. A quantitative approach is carried out to see the achievement of the scores obtained by a blind student of Extraordinary Junior High School against MCC score (Minimum Completeness Criteria). In class VII-A of this School there is only one blind student. The blind student is said to have Good academic achievement, if the average value he gets is greater than or equal to the MCC score. At this Extraordinary Junior High School, the set MCC is 70.00. The qualitative approach is carried out through a series of classroom observation activities and the use of manipulative props, interviews with the blind student, and triangulation. Data analysis was carried out through data reduction, data exposure, data interpretation, and conclusion drawing **(DePountis, Pogrund, Griffin-Shirley, & Lan, 2015)**. Research Subject in this research is one person of blind student, of class VII-A of State Extraordinary Junior High School of Salatiga of Indonesia.

3.3. Research Instrument

A test to reveal the growth of the blind students' mathematical imagination, a research instrument was made in the form of 6 math problems. Each problem is done by the blind student, according to steps of the 6 indicators of the emergence of mathematical imagination. Problems to reveal the growth of mathematical imagination have been through Expert Validation. The test is carried out after learning by applying inquiry-based learning assisted by manipulative props. According to, **Sugiman, Sugiharti, & Kurniawati (2018)** to measure the increase in the growth of the blind students' mathematical imagination, it is marked by the emergence of indicators as written in **Table 1**. Interviews were conducted to ensure the blind students' answers related to the tests that had been carried out. Interviews are conducted after student has finished working on the problems and collected answers. Triangulation was also strengthened by interviews by researchers with the class teacher about the applied learning models and the use of manipulative props.

4. Results and Discussion

4.1. Research Implementation

The researcher conducted in SMPLB Negeri Salatiga, start by doing orientation in school on August 21, 2018, until September 19, 2018. Orientation to know more information about curiculum, learning, and mathematical props in SMPLB Negeri Salatiga, especially for blind students/ This orientation

activity include interview with class teacher. Meanwhile, taking reasearch data conducted on January 14, 2020 until February 4, 2020.

4.2. Research Result

a. Mathematical Imagination of the Blind Students

The blind students' mathematical imagination in inquiry-based learning assisted with manipulative props increases during the research. In this research, there were 3 tests, each of which contained 2 problems. Problems 1 and 2 were done by the blind student without using manipulative teaching props (Initial Working phase). Problems 3 and 4 were done by the blind student using manipulative teaching props (Intervention phase). Problems 5 and 6 were done by the blind student without using manipulative teaching props. The result of mathematical imagination of the blind student through quantitative approach are as follows:

Table 3. Mathematical Imagination Score Test

	Problem Number	Score	Mean
Initial Working	1	40	70,83
	2	45	
	3	65	
Intervention	4	85	
	5	95	
	6	95	

Based on the Graph above, it can be seen the tendency line of increasing the learning outcomes of the subject's mathematical imagination at each phase. The Initial Working phase shows the upward tendency line, and in the Intervention phase also shows the upward tendency line.

The conclusion. Thus, due to the application of inquiry-based learning with manipulative teaching props, it has succeeded in increasing the mathematical imagination of the blind student in learning mathematics, especially through the subject matter of circles.

b. Achievement of Test Scores against Minimum Completeness Criteria

Every school in Indonesia, including of Extraordinary Junior High School (SMPLB) of Salatiga, must determine the Minimum Completeness Criteria (MCC), which is the minimum score that must be achieved by each student for each subject. In class VIIA at SMPLB of Salatiga for Mathematics subject, the MCC is set of 60.00. On the other hand, based on Table 2 above, it appears that the mean of the blind student test score = 70.83. Because 70.83 > 60.00 means that the average score achieved by the blind student is greater than 60.00. If the mean score of student is above the CMM value, it means that the blind student concerned has the Good category.

The categories:

1) If the mean < 60.00, the criteria for student to has the Less category.

2) If 60.00 ≤ mean < 70.00, the criteria for students to has the Medium category.

3) If 70.00 ≤ mean < 85.00, the criteria for student to has the Good category.

4) If 85.00 ≤ mean ≤ 100.00, the criteria for student to be in the Very Good category.

c. The Benefit of Manipulative Props in Increasing the Mathematical Imagination of Blind Students

The describing of the benefits of manipulative props in increasing the blind students' mathematical imagination through materials of circle circumference and area, using inquiry-based learning can be seen in the table below. Table 3 below show about test result and the analysis for mathematical imagination test of Problem 1 or test that given to the blind student before using inquiry-based learning with manipulative props. Also, given imagination test result based-on Quantitative Skor and Qualitative Assessment. Based on Table 2 above, the work on Problem Number 1 has the Less category.

Table4. Data of Mathematical Imagination based-on Test of Problem Number 1

Mathematical Imagination of the Blind Student				
Aspects	Indicators	Quantitative Skor	Qualitative Assessment	Categories
Scientific Sensitivity (SS)	(1)	70	Good	Less (40)
	(2)	70	Good	
Scientific Creativity (SC)	(3)	20	Less	
	(4)	80	Good	
Scientific Productivity (SP)	(5)	0	Very Less	
	(6)	0	Very Less	

Table 5 below show about test result and the analysis for mathematical imaginationa test of Problem 2 or test that given to the blind student before using inquiry-based learning with manipulative props. Also, given imagination test result based-on Quantitative Skor and Qualitative Assessment. Same as in **Table 4,** then based on Table 2 above, the work on Problem Number 2 has the Less category. category.

Table 5. Data of Mathematical Imagination based-on Test of Problem Number 2

Mathematical Imagination of the Blind Student				
Aspects	Indicators	Quantitative Skor	Qualitative Assessment	Categories
Scientific Sensitivity (SS)	(1)	90	Good	Less (45)
	(2)	80	Good	
Scientific Creativity (SC)	(3)	20	Less	
	(4)	80	Good	
Scientific Productivity (SP)	(5)	0	Very Less	
	(6)	0	Very Less	

Table 6 below show about test result and the analysis for mathematical imagination test of Problem 3 or test that given to the blind student before using inquiry-based learning with manipulative props. Also, given imagination test result based-on Quantitative Skor and Qualitative Assessment. Based on **Table 2** above, the work on Problem Number 3 has the Medium category.

Table 6. Data of Mathematical Imagination based-on Test of Problem Number 3

Mathematical Imagination of the Blind Student				
Aspects	Indicators	Quantitative Skor	Qualitative Assessment	Categories
Scientific Sensitivity (SS)	(1)	90	Good	Medium (65)
	(2)	85	Good	
Scientific Creativity (SC)	(3)	70	Good	
	(4)	80	Good	
Scientific Productivity (SP)	(5)	45	Less	
	(6)	20	Very Less	

Table 7 below show about test result and the analysis for mathematical imaginations test of Problem 4 or test that given to the blind student before using inquiry-based learning with manipulative props. Also, given imagination test result based-on Quantitative Skor and Qualitative Assessment. By using the provisions in **Table 2** above, the work on Problem Number 4 is in the Very Good category.

Table7. Data of Mathematical Imagination based-on Test of Problem Number 4

Mathematical Imagination of the Blind Student				
Aspects	Indicators	Quantitative Skor	Qualitative Assessment	Categories
Scientific Sensitivity (SS)	(1)	85	Very Good	Very Good (85)
	(2)	85	Very Good	
Scientific Creativity (SC)	(3)	85	Very Good	
	(4)	85	Very Good	
Scientific Productivity (SP)	(5)	85	Very Good	
	(6)	85	Very Good	

Table 8 below show about test result and the analysis for mathematical imagination test of Problem 5 or test that given to the blind student before using inquiry-based learning with manipulative props. Also, given imagination test result based-on Quantitative Skor and Qualitative Assessment. By using the provisions in **Table 2** above, the work on Problem Number 5 is in the Very Good category.

Table 8. Data of Mathematical Imagination based-on Test of Problem Number 5

Mathematical Imagination of the Blind Student				
Aspects	Indicators	Quantitative Skor	Qualitative Assessment	Categories
Scientific Sensitivity (SS)	(1)	100	Very Good	Very Good (95)
	(2)	100	Very Good	

Scientific Creativity	(3)	95	Very Good
(SC)	(4)	80	Very Good
Scientific Productivity	(5)	100	Very Good
(SP)	(6)	95	Very Good

Table 9 below show about test result and the analysis for mathematical imagination test of Problem 6 or test that given to the blind student before using inquiry-based learning with manipulative props. Also, given imagination test result based-on Quantitative Skor and Qualitative Assessment. Same as in Table 7 and 8, then based on **Table 2** above, the work on Problem Number 6 has the Very Good category.

Table 9. Data of Mathematical Imagination based-on Test of Problem Number 6

Mathematical Imagination of the Blind Student				
Aspects	Indicators	Quantitative Skor	Qualitative Assessment	Categories
Scientific Sensitivity	(1)	100	Good	Very Good (95)
(SS)	(2)	100	Good	
Scientific Creativity	(3)	95	Less	
(SC)	(4)	80	Good	
Scientific Productivity	(5)	100	Very Less	
(SP)	(6)	95	Very Less	

The mathematical imagination aspects that appear are Scientific Sensitivity (SS), Scientific Creativity (SC), and Scientific Productivity (SP) in good categories. The use of subject props is classified as good. The role of the props in the session 6 question test in increasing mathematical imagination is already in the good category.

The conclusion. Based on a qualitative approach, the results of the work of the blind student has been obtained in utilizing manipulative teaching props. There was a significant increase in student work results, from the category Less, Less again, and when the blind student was using the manipulative teaching props there was an increase in the categories of Medium and Very Good. Finally, after being skilled at working on the problems with the aid of teaching props, this blind student worked on the problems smoothly without the aid of the teaching props. The category remains Very Good twice in a row. This shows that the use of manipulative teaching props in mathematics learning has significant benefits for efforts to improve the ability of the blind students in mathematics.

5. Discussions

5.1. Increase of Mathematical Imagination of the Blind Students

Mathematical imagination is the thinking power of the blind students in the imagination that gains experience from the learning process and exercises. If they have difficulty solving a problem, students find creative or alternative ways to solve the problem. The mathematical imagination in this study is formulated based on (Ramey et al., 2016; Liang, Chang, Chang, & Lin, 2012) which is divided into 3

aspects, namely (1) Scientific Sensitivity aspect or SS which is a mathematical thinking power characterized by Emotional Undestanding and the Experience of Imagination. (2) Scientific Creativity aspect is an aspect of mathematical imagination which in its application involves ways and strategies in solving mathematical problems that have a diversity and students are able to explore mathematical problems that have been provided by recalling the rules applied in problem solving. This Scientific Creativity aspect is a creative mathematical imagination which is the power of mathematical thinking that is able to generate new ideas and is able to transfer these new ideas to solve mathematics independently or originality. Creative mathematics imagination in its application to solve math problems students are trained to be able to find new ideas that the teacher has never explained in solving math problems. (3) Scientific Productivity aspect in mathematical imagination is the power of mathematical thinking that is able to produce correct and effective completion steps based on experiences that have been experienced. In the application of this productive mathematical imagination, students are also expected to be able to find other ways / solutions in solving their problems. Students' answers need to be matched with the question of its problem.

Based on the results of a mathematics test conducted with the Initial Working phase (first test), the second test in the Intervention phase was conducted where student worked on problems with the help of manipulative props and the third test students worked on math problems without using a manipulative teaching props. It can be explained that there was an increase in the score of the test results carried out based on the mathematical imagination of the blind student of SMPLB of Salatiga after the blind student carried out the phases of using inquiry-based learning with manipulative teaching props. The blind student test score = 70.83 and CMM = 60.00. Because 70.83 > 60.00 means that the average score achieved by the blind student is greater than 60.00. If the mean score of student is greater than the MCC value, it means that this blind student concerned has the Good category.

This result was confirmed by comparing the mean obtained by the blind students with MCC. Blind students are included in the High criteria.

That is, due to the application of inquiry-based learning with manipulative teaching props, it has succeeded in increasing the mathematical imagination of the blind student in learning mathematics, especially through the subject matter of circles.

5.2. The Benefit of Manipulative Props in Increasing Mathematical Imagination of the Blind Students

The results of the mathematics imagination test session 1, Problem Number 1 in Table 4, the results of the work by the research subject showed that the blind student showed indicators of mathematical imagination in the Less category because the research subject was only able to answer Good on indicators Number (1), (2), and (4). This means that the blind student fail to do the problem. However, the indicators: (1) Emotional Understanding, (2) the Experience of Imagination (EI), and (4) Originality (O) were in the Good category. Others were in the Less category.

Table 5 shows the results of the math imagination problem test for session 2, Problem Number 2. Similar to the results of the work on Problem Number 1, the results of working on problem number 2 were still disappointing. The category was still Less. The blind student has not been introduced to manipulative teaching props. Assessment of work results in the Good category is only on the

indicators: (1) Emotional Understanding, (2) the Experience of Imagination (EI), and (4) Originality (O). Meanwhile, other indicators were still in the Less category.

Before working on Problem Number 3 and Number 4, the blind student is given training in using manipulative teaching props and were trained to work on problems with the help of these manipulative teaching props. The results of the test of math imagination problem of session 3, Problem Number 3 in Table 5 shows that the research subject has been able to use manipulative teaching props and apply them to answer number 3. With the aid of manipulatitive teaching props, the blind student began to successfully spell it out with a good score from indicator 1 to indicator 4, namely Emotional Understanding (EU), the Experience of Imagination (EI), Diversity (D), and Originality (O). This means that with the help of manipulative teaching props, the blind student can begin to apply them to work on problems. The blind student managed to show an increase in their qualitative scores into the Medium category. Student work looks good on the indicator of Emotional Understanding (EU), where the blind student is able to explore what is known in the given math problems. Then the Experience of Imaginative (EI) indicator appear where the blind student is able to write the ask of a given math problem. The Diversity (D) indicator, where student is able to come up with ideas to answer its questions. Then the indicator of Originality (O) appears that the student is able to work alone in solving it. Meanwhile, other indicators were still in the Less category.

In working on Problem Number 3 and Number 4, the blind student uses manipulative teaching props. The results of the test on math imagination problem of session 4, Problem Number 4 in Table 7 show that the research subject was able to use manipulative teaching props and apply them to answer number 4 perfectly. With the aid of manipulative teaching props, the blind student has successfully spelled it out with a score that is Very Good from indicator 1 to indicator 6, namely Emotional Understanding (EU), the Experience of Imagination (EI), Diversity (D), Originality (O), Creation and Reproduction (CR), and Scientific Sense of Reality (SSR). That is, with the help of manipulative teaching props, the blind student can apply them to work on problems. The blind student managed to show an increase in his qualitative score into the Medium to Very Good category. The blind student was able to do the problem correctly in order, detail, and correctly. All indicators have been met, namely indicators of Emotional Understanding (EU), the Experience of Imagination (EI), Diversity (D), Originality (O), Creation and Reproduction (CR), and Scientific Sense of Reality (SSR) which have a qualitative value of Very Good.

After student was deemed proficient in using manipulative teaching props that were used as aids to work on problems, then in working on problems number 5 and 6, the blind student no longer use manipulative teaching props to work on the problems given. The results of the test on math imagination problem of session 5, Problem Number 5 in Table 8 show that the research subject was able to answer number 5 perfectly without using manipulative teaching props. With the help of visual aids, the blind student has succeeded in doing it with a score that is Very Good from indicator 1 to indicator 6, namely Emotional Understanding (EU), the Experience of Imagination (EI), Diversity (D), Originality (O), Creation and Reproduction (CR), and Scientific Sense of Reality (SSR). This means that without the help of manipulative teaching props, the blind student can works on the problem. Blind students managed to maintain their qualitative scores into the Very Good category. The blind student was able to do the problem correctly in order, detail, and correctly. All indicators have been met, namely indicators of Emotional Understanding (EU), the Experience of Imagination (EI), Diversity (D),

Originality (O), Creation and Reproduction (CR), and Scientific Sense of Reality (SSR) which have a qualitative value of Very Good too.

In **Table 9**, it shows again that the blind student was successful in working on Mathematical Imagination problem without using his manipulative teaching props. Student was also able to work on given math problems with steps that show his ability in his Mathematical Imagination. Student did it correctly, in order, and completely. As in the work of problem number 5, ask number 6 was also done by this research subject in the Very Good category. All indicators have been met, namely indicators of Emotional Understanding (EU), the Experience of Imagination (EI), Diversity (D), Originality (O), Creation and Reproduction (CR), and Scientific Sense of Reality (SSR) which have a qualitative value of Very Good.

Development or the gowth of mathematical imagionation of blind students after following learning using inquiry-based learning with manipulative props are showed in this **table 10** below.

Table 10. The Increase of the Blind Students' Mathematical Imagination

Initial Working Phase	Intervention Phase
Session 1 Problem 1 Mathematical Imagination Category: Less Scientific Sensitivity (SS): (1) Good; and (2) Good Scientific Creativity (SC): (3) Less; and (4) Good Scientific Productivity (SP); (5) Very Less; and (6) Very Less	Session 3 Problem 3 Mathematical Imagination Category: Medium Scientific Sensitivity (SS): (1) Good; and (2) Good Scientific Creativity (SC): (3) Less; and (4) Good Scientific Productivity (SP); (5) Good; and (6) Very Less
	Session 4 Problem 4 Mathematical Imagination Category: Very Good Scientific Sensitivity (SS): (1) Very Good; and (2) Very Good Scientific Creativity (SC): (3) Very Good; and (4) Very Good Scientific Productivity (SP); (5) Very Good; and (6) Very Good
Session 2 Problem 2 Mathematical Imagination Category: Less Scientific Sensitivity (SS): (1) Good; and (2) Good Scientific Creativity (SC): (3) Less; and (4) Good Scientific Productivity (SP); (5) Very Less; and (6) Very Less	Session 5 Problem 5 Mathematical Imagination Category: Very Good Scientific Sensitivity (SS): (1) Very Good; and (2) Very Good Scientific Creativity (SC): (3) Very Good; and (4) Very Good Scientific Productivity (SP); (5) Very Good; and (6) Very Good

	Session 6 Problem 6 Mathematical Imagination Category: Very Good Scientific Sensitivity (SS): (1) Very Good; and (2) Very Good Scientific Creativity (SC): (3) Very Good; and (4) Very Good Scientific Productivity (SP); (5) Very Good; and (6) Very Good

Based on the description above and **Table 10**, it can be explained that inquiry-based learning assisted with manipulative teaching props is able to foster the mathematical imagination of the blind students. This shows that there is an increase in the growth of mathematical imagination from each test, from test of Problem 1 to test of Problem 6. These results can be explained that the application of inquiry-based learning will improve the quality of learning, because in this model student is given the opportunity to explore related topics being studied, so that student will build a critical thinking through the direct inquiry process. Cognitive skills developed by student can be used to improve understanding of each material and its problems, so that it can increase or foster their mathematical imagination. The growth of the blind students' mathematical imagination is also strengthened by the use of manipulative props which are useful for helping the blind student in understanding abstract mathematical concepts to be concrete. With the help of appropriate teaching props and inquiry-based learning models, the blind student can understand the basic ideas that underlie a concept, know the use of formulas or theorems, and can use them in solving problems. According to Suwardi, with the help of manipulative teaching props, learning concentration can be further improved, it can also help the blind student think logically and systematically, so that in the end he has the mindset needed to solve math problems. Thus, the Inquiry Based Learning model with manipulative mathematics teaching aids can increase the mathematical imagination of the blind student in the Extraordinary Junior High School.

6. Conclusions and Recommendations

Based on the results of this research on increasing the mathematical imagination of the blind student through the application of inquiry-based learning with manipulative teaching props, then the following conclusion were obtained: (1) due to the application of inquiry-based learning with manipulative teaching props, it has succeeded in increasing the mathematical imagination of the blind student in learning mathematics, especially through the subject matter of circles; (2) Based on a qualitative approach, the results of the work of the blind student has been obtained in utilizing manipulative teaching props. There was a significant increase in student work results, from the category Less, Less again, and when the blind student was using the manipulative teaching props there was an increase in the categories of Medium and Very Good. Finally, after being skilled at working on the problems with the aid of teaching props, this blind student worked on the problems smoothly without the aid of the teaching props. The category remains Very Good twice in a row. This shows that the use of manipulative teaching props in mathematics learning has significant benefits for efforts to improve the ability of the blind students in mathematics.

The recommendations are as follows: Manipulative teaching props have important benefits in increasing the mathematical imagination of the blind students through the subject matter of the circumference of the circle and the area of the circle. Therefore, it is recommended that mathematics teachers at Extraordinary Junior High School can apply the use of manipulative teaching props which use the application of Inquiry based learning too.

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References

[1]. Adebisi, R. O., Liman, N. A., & Longpoe, P. K. (2015). Using Assistive Technology in Teaching Children with Learning Disabilities in the 21st Century. *Journal of Education and Practice*, 6(24), 14-20.

[2]. Akakandelwa, A., & Munsanje, J. (2012). Provision of learning and teaching materials for pupils with visual impairment: Results from a national survey in Zambia. *British Journal of Visual Impairment*, 30(1), 42-49.

[3]. Caiman, C., & Lundegård, I. (2018). Young children's imagination in science education and education for sustainability. *Cultural Studies of Science Education*, 13(3), 687-705.

[4]. DePountis, VM., Pogrund, RL., Griffin-Shirley, N., and Lan, WY. (2015). Technologies that Facilitate the Study of Advanced Mathematics By Students Who Are Blind: Teachers' Perspectives. *International Journal of Special Education*, 30(2).

[5]. Hidayah, I., & Sugiarto. (2014). The Implementation of Teacher Leadership in Mathematic Learning Through A Series of Productive Question. *Proceding International Conference on Mathematics, Science, and Education*. Semarang: Semarang State University.

[6]. Hudson, M. E., Zambone, A., & Brickhouse, J. (2015). Teaching Early Numeracy Skills Using Single Switch Voice-Output Devices to Students with Severe Multiple Disabilities. *Journal of Developmental and Physical Disabilities*, 28(1), 153–175.

[7]. Klingenberg, O. G., Holkesvik, A. H., Augestad, L. B., & Erdem, E. (2019). Research evidence for mathematics education for students with visual impairment: A systematic review. *Cogent Education,* 6(1), 1626322.

[8]. Lersilp, T. (2016). Assistive Technology and Educational Services for Undergraduate Students with Disabilities at Universities in the Northern Thailand. *Procedia Environmental Sciences*, 36, 61- 64.

[9]. Liang, C., Chang, C. C., & Hsu, Y. (2013) Differential effects of personality traits and environmental predictors on reproductive and creative imagination. *The Journal of Creative Behavior*, 48(4), 237-253.

[10] Liang, Chaoyun, Chang, Ch-Cheng, Chang, Yuhsuan, & Lin, Li-Jhong. (2012). The Exploration of Indicators of Imagination. *The Turkish online Journal of Educational Technology*, 11(3), 366-374.

[11]. Mun, J., Mun, K., & Kim, S. W. (2015). Exploration of Korean students' scientific imagination using the scientific imagination inventory. *International Journal of Science Education*, 37(13), 2091-2112.

[12]. Ramey, D., Lydon, S., Healy, O., McCoy, A., Holloway, J., & Mulhern, T. (2016) A Systematic Review of the Effectiveness of Precision Teaching for Individuals with Developmental Disabilities. *Review Journal of Autism and Developmental Disorders*, 3(3), 179–195.

[13]. Republic of Indonesia. (2016). Undang-Undang Republik Indonesia No. 8 Tahun 2016 Tentang Penyandang Disabilitas.

[14]. Rosenblum, L. P., Hong, S., & Amato, S. (2013). The Abacus: Teachers' Preparation and Beliefs about their Abacus Preservice Preparation. *Journal of Visual Impairment & Blindness*, 107(4), 274–285.

[15]. Sugiman, Sugiharti, E., & Kurniawati, N. F. (2018). Growing of the mathematical thinking imaginative to students in designing of the teaching aids for CWD towards to joyful learning. *Journal of Physics: Conference Series*, 983(012079).

[16]. Toheri, T., Winarso, W., & Haqq, A.A. (2020). Where Exactly For Enhance Critical And Creative Thinking: The Use Of Problem Posing Or Contextual Learning. *European Journal of Educational Research, 9*(2), 877-887.

[17]. Wibowo, T., Sutawidjaja, A., As' ari, A. R., & Sulandra, I. (2017). The Stages of Student Mathematical Imagination in Solving Mathematical Problems. *International Education Studies*, 10(7), 48-58.

[18]. Widiyatmoko, A. (2013). Pengembangan perangkat pembelajaran ipa terpadu berkarakter menggunakan pendekatan humanistik berbantu alat peraga murah. Jurnal Pendidikan IPA Indonesia, 2(1), 76-82.

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