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Bead Maze Media Semiotics Objects: A Study of Mathematics Teaching for Autism Students in Elementary School

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ABSTRAK

Pembelajaran matematika pada siswa autis perlu dilakukan secara konkrit dan menarik. Jika hal ini diterapkan, diharapkan siswa autis mampu memahami bahkan menggunakan matematika dalam kehidupan sehari-hari. Tujuan penelitian ini adalah menganalisis objek semiotik media bead maze pembelajaran matematika untuk siswa autis di sekolah dasar. Penelitian dilakukan secara deskriptif kualitatif. Metode pengumpulan data melalui observasi, dokumentasi, dan wawancara dengan guru matematika sekolah dasar dan juga pendamping siswa autis. Observasi dilakukan dengan mengamati media adaptif bead maze. Objek yang dapat diamati adalah manik-manik yang ada didalamnya seperti bentuk dan warnanya yang berbeda-beda. Wawancara dilakukan pada satu siswa autis kelas tiga, guru matematika sekolah dasar dan guru pendamping. Data yang diperoleh dari observasi, dokumentasi, dan wawancara kemudian dianalisis dengan menggunakan triangulasi metode. Metodologi triangulasi dilakukan dengan membandingkan informasi yang diperoleh dari observasi, dokumentasi, dan wawancara. Hasil penelitian menemukan enam objek primer semiotik, yaitu bahasa, situasi masalah, konsep, prosedur, properti, dan argument telah diidentifikasi berdasarkan konsep matematika dasar (bilangan, aljabar, geometri, pengukuran) yang sedang dipelajari di kelas tiga. Setiap objek semiotic pada media bead maze berpotensi meningkatkan aktivitas matematis siswa yang kontekstual, menarik, dan bermakna bagi siswa autis di sekolah dasar.

ABSTRACT

Mathematics learning for autistic students needs to be done concretely and interestingly. If this is implemented, it is hoped that autistic students will be able to understand and even use mathematics in everyday life. This study aimed to analyze semiotic objects in the bead maze media for learning mathematics for autistic students in elementary schools. The research was conducted in a descriptive qualitative manner. Methods of data collection through observation, documentation, and interviews with elementary school mathematics teachers and assistants for autistic students. Observations were made by observing the bead maze adaptive media. Objects that can be observed are the beads in it, such as different shapes and colors. Interviews were conducted with one third-grade autistic student, an elementary school math teacher, and an assistant teacher. Data obtained from observation, documentation, and interviews were then analyzed using triangulation. The triangulation methodology is carried out by comparing the information obtained from observation, documentation, and interviews. The study results found that six primary semiotic objects, namely language, problem situations, concepts, procedures, properties, and arguments, have been identified based on basic mathematical concepts (numbers, algebra, geometry, measurement) being studied in the third grade. Each semiotic object in bead maze media can potentially increase students' mathematical activities, which are contextual, interesting, and meaningful for autistic students in elementary schools.

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1. INTRODUCTION

There are several types of students with special needs in elementary schools, one of which is autistic students. Autistic students have abnormalities in ongoing development significantly. This matter is influential on communication nonverbal, verbal, and interaction it is social (Carpenter, 2020; Klin et al., 2020). Generally, this abnormality occurs before age three years. In addition, autistic students will do repetitive activities and movements stereotypes, denial to change environments or changes in routine daily as well as not respond should experience sensory. Paying attention to the abnormalities that autistic students have, and learning with their peers is beneficial to raise several occasions. Such an opportunity for observing, starting interaction social, responding bid social, and playing with friends and peers (Cañete et al., 2021; Park et al., 2020). The results showed an increase in interaction social Skills communication and activities groups with peers. Furthermore, the factors also presented that affect the learning process of autistic students, namely curriculum, method e-learning, and lack of facility support such as learning media (Park et al., 2020; Yasamin Bolourian & Jan Blacher, 2016). Most of the class teachers and assistant teachers of autistic students do not train to develop learning media for autistic students (Ekowati, 2017; Suwandayani et al., 2021). Although autistic students are not own disabilities intellectual and cognitive abilities are well-developed. But learning media is needed because it has the function to bridge the cognitive abilities of autistic students with the material being studied (Yasamin Bolourian & Jan Blacher, 2016). Especially in studying abstract subjects such as mathematics (Ekowati et al., 2021; Suwandayani et al., 2020). This is because the language in mathematics is in the form of terms, symbols, signs, or symbols (Ekowati & Suwandayani, 2020; Wulandari et al., 2021). It is hoped that the existence of learning media can bridge the abstractness of mathematics (Juan D Godino et al., 2011; Pino-Fan et al., 2018).

When studying mathematics, autistic students need to be facilitated to think about mathematics and communicate the results of students thoughts orally or in writing and learn to explain and convince what is on students' minds (Klin et al., 2020; Kozhemyakin & Lovyagina, 2020). The main concern in learning mathematics involving autistic students is how to bridge autistic students to be able to think mathematically and communicate the results of students' thinking so that student's potential can be optimally developed in their peer environment (Siregar et al., 2020; Van Tran et al., 2020). To realize such mathematics learning, teachers must be able to present learning strategies and media that can bridge autistic students in mathematics activities (Calder, 2012; Olteanu, 2021). The introduction of explicit mathematical media along with the process of mathematical activity is a competency that must be developed by teachers (Juan D Godino et al., 2017; Kjällander et al., 2021). However, this is a challenge in itself, because most elementary school teachers in Indonesia have a scientific background from elementary school teacher education study programs and not from the scientific field of mathematics education (Ekowati et al., 2021). Although there are accompanying teachers for autistic students, not all accompanying teachers have strong mathematical knowledge.

Several studies have stated that the accompanying teacher's limited knowledge of math content makes it difficult for teachers to interpret the answers of autistic students (Burgos & Godino, 2020; De Almeida & Da Silva, 2018). On the other hand, content knowledge is not enough for teachers to recognize autistic students' mathematical understanding. Therefore, teacher preparation must consider the development of didactic-math knowledge and competence (Burgos et al., 2020; L MW De Almeida & Da Silva, 2018). Developing didactic-mathematical knowledge and competence can be done by identifying mathematical elements that are relevant to the learning strategy or media used by the teacher (Bianchini et al., 2019; Mariotti, 2013). The elements referred to are related to mathematical terms, symbols, and symbols (Fatimah et al., 2020; Hagiwara et al., 2019).

Understanding terms, symbols, and symbols is one of the determinants of whether autistic students think mathematically and communicate the results of their thinking during the mathematics learning process (Burgos & Godino, 2020; Siregar et al., 2020). Adaptive media is seen as a suitable learning medium for autistic students (Martikainen & Sakki, 2021). Adaptive media is made and used according to the conditions and needs of autistic students. In elementary schools, pious children also use adaptive bead maze media to teach mathematical concepts. Teachers have difficulty using adaptive bead maze media to learn mathematics. The use of media is limited to matching the existing mathematical flat planes on the media. In addition to flat fields, teachers have difficulty teaching in the classroom. In this research, adaptive media is focused on bead maze media. This bead labyrinth media is in the form of a bead maze which is equipped with a series of stages of its use. How the teacher bridges the abstractness of mathematics by using a contextual mathematical object in the form of a maze of beads is the focus of this study. The process of bridging contextual mathematical objects with mathematical concepts is by analyzing the terms, symbols, signs, and symbols that exist in the bead maze media. Concepts that study terms, symbols, signs, or symbols are called semiotics concepts. *Charles S. Peirce* originally introduced semiotics to learn terms, symbols, signs, or symbols (Abbas & Kadim, 2019; Lukianova & Fell, 2015). On

the other hand, a term, symbol, sign, or symbol is language in mathematics. Moment study math will be difficult to study and think mathematics without using clear terms, symbols, signs, or symbols (Juan D Godino et al., 2011). The most basic problem related to terms, symbols, signs, or symbols used on objects in mathematics. This is because semiotics is used to explain the relationship or function between expressions/markers and the meaning determined by the subject (person or institution) according to certain criteria (Juan D Godino et al., 2017; Shapiro, 2014). So far, the terms semiotic and autistic have been listed in semiotic perspective research on mobile applications and technology used by autistic students (Alper, 2018; Hoxha, 2016; Suha et al., 2022). In the last 10 years, there has been no semiotic analysis of concrete media used by autistic students in elementary schools. Research on learning processes in the classroom is still limited to making paper prototypes for autistic students using semiotic research methods (Braz et al., 2014). On the other hand, concrete media corresponds to the stages of learning development of elementary school students, namely concrete operations (Jaynelle G. Domingo et al., 2021).

Research related to the learning media used by autistic students is very important and helps elementary school teachers. It should be noted that the majority of elementary school teachers in Indonesia have a scientific background from the primary school teacher education study program and not from the scientific field of mathematics education. So that the depth of mathematical concepts and the meaningfulness of learning media for autistic students is largely determined by the understanding of each elementary school teacher. Therefore, the process of analyzing semiotic objects in bead maze media is expected to help teachers in elementary schools when facilitating autistic students in learning mathematics in elementary schools. Taking into account the description above, it is very important to analyze the semiotic object of learning mathematics in the manic maze media for autistic students in elementary schools. So the purpose of this study was to analyze the semiotic object of the bead maze media for learning mathematics for autistic students in elementary schools.

2. METHOD

The approach and type of research are qualitative and descriptive. The selection of qualitative descriptive research aims to get meaningful comprehensive information and deep (R. Burke Johnson & Larry Christensen, 2014). The purpose study is to do an analysis of semiotic object learning bead maze media mathematics for autistic students in elementary school. The research steps are presented in Figure 1. Conception uses six objects main semiotics forms the basis of research design, ie language, situation problem, concept, procedure, property, and argument showed in Table 1.

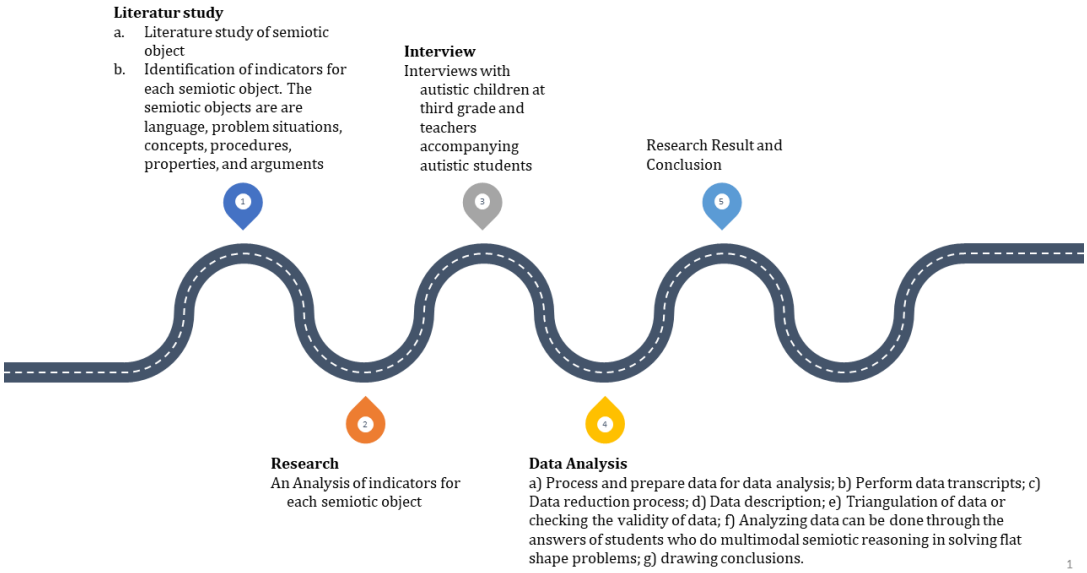

Figure 1. Research Flowchart

Table 1. The Semiotic Objects

Number	The Semiotic Objects	The Definition
1	Language	A language includes symbols, terms, and signs/symbols both in writing, orally, signs, and in representations
2	Problem situation	The problem situations, i.e. applications extra-mathematical and training
3	Concept	For example, the definitions of number, point, rectangular, addition etc.
4	Proposition	The proposition is a statement about the concept that requires justification
5	Procedure	Procedures include algorithms, operations, and techniques calculations: addition, subtraction, multiplication, and division
6	Argument	An argument is a statement used to justify or validate or explain propositions and procedures, whether argument the deductive or otherwise

(Burgos & Godino, 2020)

The research location is Anak Shaleh elementary school in Malang City. The research subject was 1 autistic student in grade 3. Observations were made when students and teachers used the bead maze media in learning mathematics. The research entitled "Bead maze media semiotics objects: a study of mathematics teaching for autism students In Elementary School" uses data and data sources, as follows: first, The qualitative data collected includes: the results of analyzing the 6 semiotic objects contained in the bead maze media. Second, the data source in this study came from 3rd-grade autistic students at Anak Shaleh Elementary School of Malang City and autistic teachers.

The procedure carried out in this study includes several stages as follows. First, Preparation Stage. The activity carried out at this stage is to make instruments for each semiotic object. Second, Data Collection Stage. Activities carried out at the data collection stage are researchers analyzing semiotic objects in bead maze media. Furthermore, any information on semiotic objects collected by researchers was confirmed by students and teachers accompanying autistic students. Third, Data Analysis Phase. At this stage, the researcher analyzes the data that has been collected during the research process. Fourth, the conclusion stage. Drawing conclusions based on research information about semiotic objects in bead maze media. Researchers as the main instrument, make research plans, design research instruments, carry out research, collect and analyze data, conclude and make research reports. To support the implementation of the research, the researcher also supports it by using observation sheets, interview guidelines, and a grid of data collection instruments. A complete explanation of data collection activities as shown in Table 2.

Table 2. The Data Collection Activities

Type	Strategy	Instrument Grids
Observation sheets	the researcher collected data on student activity when using bead maze media	1. Identification of objects/signs/symbols on bead maze media. 2. Identification of written, spoken, sign, or representation. 3. Examine the problem situation used by the teacher using bead maze media 4. Manipulation of bead maze media to construct the concept 5. Explain the meaning of the concept of using the media 6. Student statements about concepts that require justification 7. Use of procedures (algorithms, operations, techniques calculations, etc.) 8. Statements submitted by students
student note sheets when using bead maze media	Sheets containing student notes when using bead maze media	Researchers collect the results of student investigations when using bead maze media
Interview guidelines	Researchers conducted interviews with research subjects	Researchers conducted interviews with research subjects based on the results of student note sheets in using bead maze media

Data analysis in this study followed the modification and needs analysis stages of qualitative research according to Creswell (Creswell, 2009). The following are the steps that will be carried out in the analysis of this data a) Processing and preparing data for data analysis; b) Data transcript; c) Data reduction; d) Data description; e) Data triangulation or data validity checking; f) Presenting the results of data analysis; g) Making conclusions.

3. RESULT AND DISCUSSION

Result

Media bead mazes are used as a tool to help supervise teacher communication, especially during the learning process of mathematics in third-grade autistic students. The mathematical material being studied is material arithmetic operations. The use of bead maze media is analyzed based on six semiotic objects. The six objects are language, problem situation, concepts, procedures, properties, and arguments. every object is explained based on the indicators each has. Language is something object first in the use of words/ terms, expressions good in shape written, oral, or gesture (Wee & Goh, 2019). Written language is a language written by someone above paper or books and read by others. In bead maze media, language is embodied in the form of a guidebook for the use of Bead Maze media in learning mathematics material. The guidebook lists are; Introduction to the rules of how to play Bead Maze. Mediabead maze manipulation (hold /touch/use), Explanation of the parts of the bead maze media (shape and color), and The three stages are written in the guidebook that students must read. Furthermore, language objects are verbally manifested in every communication, and interaction using the media. The spoken language begins with the teacher's explanation to autistic students regarding the guidebook. Second, students requested to listen to the teacher's orders. Third, students ask and answer with the teacher's rules and play Bead Maze. Fourth, students start using bead maze media. Based on the results of observations, it is known that the use of language by teachers and students with autism is already done in two directions (teacher-student) both in writing and orally as shown in the Figure 2.

Figure 2. Media Bead Mazes and Use of Language Objects in Bead Maze Media

In other semiotic objects, problem-situation includes objects second after language. This relates to the method of solving mathematical problems. Situation mathematics by using the media bead maze questions which include numbers, algebra, geometry, measurement, and statistics. These tasks are adapted to the level of development of elementary school students. The description of the problem situation is listed in Table 3.

Table 3. Description of Problem Situations

Bead Maze media	Description of problem-situations task
Number	Autistic students use the color of the bead maze media to count the bead. Bead maze media have any color, are yellow, blue, pink, green
Algebra	In the bead maze material, Autistic students can use the beads for addition, subtraction, and division task

Bead Maze media	Description of problem-situations task
Geometry	In geometry concepts, autistic students learned a cube on Bead Maze media. Autistic students can also use the shape and color of the beads to learn the characteristics and shape material
Measurement	On measurement concepts, autistic students study measurement length, and weight using unit raw.

In general, the problem-situation semiotic object includes several problems involving the concepts of numbers, algebra, geometry, and measurement which are learned by autistic students in the third grade. Specifically, the concept of statistics in grade three has not been studied by students. However, students begin to learn to collect data from the number of beads of the same color or the same shape. This is already listed in the algebra problem-situations task. As for other semiotic objects which include concepts, propositions, and procedures, the following arguments. The concept this introduced through definition or description. In this study, the concept obtained from the results analysis problem-situation has been explained before. The proposition is a concept statement explained in the study about applied concepts in a situation problem. The procedure is step technique calculation used in every situation obtained problem from results analysis. Whereas argument forms explanation propositions and procedures. Next results analyze concepts, propositions, procedures, and arguments in the Table 4.

Table 4. Description of Concepts, Propositions, Procedures, and Arguments in Bead Maze Media

Concepts	Proposition	Procedure	Argument
Numbers include numbers original, positive, negative, odd, even, round, rational, irrational, real, and complex.	The number original is (1,2,3,4,5,6,7,8, 9, 10, ..)	- Count total blue beads _ - Count many colors on each cube.	Explanation of reinforced propositions and procedures _ with Bead Maze media.
Addition and subtraction.	sum use symbol (+) and subtraction (-)	Do addition and subtraction in numbers in every shape and color on adaptive media (bread maze).	Addition and subtraction are supported by a media bead maze that leads to operation arithmetic.
geometry	The shape of the bead maze media varies, however, resembles the shape of a cube in parts.	identify shape Miscellaneous up and their technique calculation.	Miscellaneous shapes contained in the Bead Maze media are thing concrete for identifying the definition, nature, and characteristics of a cube.
Measurement length, and weight use unit raw.	Measurement long use unit raw that is ruler. Whereas measurement heavy use unit standard i.e. kg.	• measurement technique long uses practice size ruler. • Measurement heavy and long served in situation problem general who has served as an example.	Bead section tool visual aid on Bead Maze media is used for practice to determine long unit centimeters using the ruler and standard unit from heavy.

Follow-up from the description of the information in the table is reinforced by interviews conducted with class mathematics teachers and special assistant teachers for autistic students. Based on the results interview with a third-grade math teacher is known that some information. The use of Bead Maze media that uses several beads of different colors was developed to make it easy child need special.

Autistic students are attracted by different colors. This interest is the way for students to learn mathematics properly and meaningfully. In addition to the six descriptions, object semiotics helps math teachers and tutors special to find some draft mathematics in third grade. In this case, the bead maze media is used not only for one concept but for several third-grade math concepts. Even when students describe orally or use sample picture beads, at the same time students are learning other subject concepts. The subjects related to the use of bead maze media are Indonesian language subjects, and cultural arts and crafts. Result interview with the supervising teacher specifically, the use of adaptive media (bead maze) ie could easily and training focus on learning. With this, activities in mathematics use more bead maze media interesting and meaningful for autistic students. The result of the analysis of semiotics in bead maze media becomes a reference for tutors and special math teachers to teach math concepts properly and correctly. In addition, it is also affected by the impact of accompaniment, namely the bead maze media can be used in other subjects.

Discussion

In the last 10 years, searches for research articles that mention the keywords "object semiotic", "autistic students" and "media" get research information about semiotic perspectives on mobile applications and technology used by autistic students (Alper, 2018; Hoxha, 2016; Suha et al., 2022). Semiotic analysis of concrete media used by autistic students in elementary schools is still limited to making paper prototypes for autistic students using semiotic research methods (Braz et al., 2014). The need for information related to semiotic objects that exist in mathematics learning media for learning autistic students still does not exist. On the other hand, the analysis of semiotic objects in learning media will help teachers when presenting learning media in the classroom. Because if you are not able to study semiotic objects contained in learning media. The function of the media becomes less meaningful (Ekowati et al., 2022; Tan et al., 2020). Elementary school teachers are required to have the ability to create an educational environment that is fun, meaningful, creative, dynamic and interactive (Asih & Nilakusmawati., 2017; Wasito et al., 2022). Therefore, this research is very much needed by elementary school teachers.

Based on the results of the analysis of semiotic objects, language, problem situations, concepts, proportions, procedures, and arguments explained according to the results of the found concept analysis (Duval, 2017; Giacomone et al., 2018). This language is embodied in the form of a guidebook for using bead maze media. Problem situations are in the form of questions related to the bead maze media and related to elementary school math concepts. The procedure describes the steps for using bead maze media. Properties provide object placement in learning. Meanwhile, the arguments strengthen the other five objects (Santi, 2011; Shilyaev & Shlotgauer, 2020). The utilization of bead maze media as an object in learning provides a marker for students to understand the meaning of mathematics. In the learning process, the teacher can understand the signs or symbols that exist in the bead maze media. But it is difficult to pinpoint the exact meaning of the corresponding mathematical concepts. With semiotic analysis, each semiotic object provides clarity of meaning between the sign and the meaning referred to by the bead labyrinth media so that the teacher's difficulties in connecting symbols to mathematical concepts can be minimized. Discussion of situations linking the study of manic labyrinths to mathematical concepts emerged as a didactic teaching strategy (Beltrán-Pellicer & Godino, 2020). Of course, it is still possible to come up with various meanings for the bead maze symbol. Not limited to cloth objects, but can also use all media procedures of bead maze involving various mathematical activities. It is even known from the process of making batik, that the concept of mathematics emerges through the knowledge and perspectives of people who are present and develop naturally in a certain culture, a pious child school without a formal educational process (Raffaghelli et al., 2020).

The explanation above, the procedures and symbols used by autistic students will add meaning to the bead maze media for learning mathematics. Apart from being a bridge in learning mathematics material. However, the bead labyrinth media can also accommodate other subjects such as Indonesian and cultural arts and crafts. By understanding other scientific contexts. Therefore, it is necessary to design and implement a new research cycle (at the same educational level and a higher level). The aim is to encourage the meaning of the manic maze media and mathematical activities of autistic students in everyday life as part of solving mathematical problems. And this is a joint task to develop various studies that can improve the quality of learning mathematics, especially at the elementary school level. The higher the quality of learning at the basic level, the stronger the knowledge of students at the next level (Lee et al., 2021). For student knowledge, the results of this study also have an important role for teachers accompanying autistic students who teach mathematics. The analysis of six semiotic objects in adaptive bead maze media is the development of the teacher's ability to interpret students' mathematical thinking, especially when solving problems (Ekowati et al., 2022). The use of research instruments also has an accompanying effect

in the form of increasing the teacher's ability to analyze student communication both written and verbal during learning mathematics (Leontovich, 2015; Philippe et al., 2020). The analysis of six semiotic objects in adaptive bead maze media allows the teacher to make an analysis based on student responses, recognizing right and wrong student answers. This is achieved by identifying the concepts, properties, and procedures involved, and the arguments made through various languages, as well as distinguishing objects based on their assignment of proportionality (Burgos & Godino, 2020; J D Godino et al., 2021). The use of concrete media for autistic students is a primary need so that students can learn well. Furthermore, teachers can enrich the use of concrete media when teaching autistic students. Involving students when preparing and using media is a good first step for students. Thus the students' interest in learning increases. Each teacher has a different and varied way of explaining mathematics, it doesn't matter, the important thing is that the learning process can be understood by autistic students. In the learning process, autists students depend on things concrete around them to be able to manipulate them directly. People are autistic as if live in their world (Cañete et al., 2021). Autism is a symptom of the close self itself which is a disturbance in complex development behavior with a consequence lack of ability communication connection social and emotional with other people and not depending on race, ethnicity, strata-economic, strata-social, level of education, as well type food. So need the line, students with disabled autistic more equality than the difference with his other students. Although they have many equations, however, autistic students also give challenges and tough teaching for teachers, to be able to study well (Klin et al., 2020). Therefore, bead maze media is needed for autistic students as a communication bridge immediately during learning. And supported with appropriate learning media with characteristics and needs.

4. CONCLUSION

The results of the semiotic analysis on the bead maze media state that the mathematical understanding of autistic students can be identified based on the results of autistic students' communication on each semiotic object. Teachers of autistic students can identify according to their understanding of language or understanding of problem situations given to mathematical concepts or problem-solving procedures to propositions used by students or even to arguments given by students. In this case, the arguments given are not always in the form of written answers, but also the form of oral answers. To obtain oral answers can be reached through teacher-student interaction and the interaction of autistic students with the manic maze media. Furthermore, semiotic analysis research can adapt media to the next level. There is still much that can be explored further in the relationship between adaptive media and mathematical concepts at a higher level.

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