Cognition processes of student with low functioning autism in solving mathematical problem

N Fauziyah¹*, I K Budayasa² and D Juniati²

¹Universitas Muhammadiyah Gresik, Jawa Timur, Indonesia
²Universitas Negeri Surabaya, Surabaya, Indonesia

*nfauziyah@umg.ac.id

Abstract. The purpose of this research was to describe the cognition processes of student with low functioning autism in solving mathematical problem. The subject in this research is a high school student with low functioning autism. Data was revealed through task-based interviews using instrument of mathematical problems. The cognition processes in solving mathematical problems involved understanding the problems, devising a plan, carrying out a plan, and checking to ensure the process of problem solving resulted in a correct answer. Some characteristics of autism was very perceptible during mathematical problems solving processes. The subject has difficulty in understanding the problem, even though the information in the problems is split into some simple information. The use of media provides assistance in an attempt to understand the problems even though it is not significant. The subject is unable to determine the plan of completion the problems because he has difficulty in understanding the problems. Subject provides answers that do not suitable with the question in a repetitive way. The subject speaks for itself during the process of understanding the problems.

1. Introduction
Autism is a developmental disorder characterized by difficulties in social interaction and communication. Autism also tends to have unusual behaviors that are shown by repetitive behavior or repetitive activity [1]. Autism is a group of developmental disabilities characterized by impairment in reciprocal social interactions, abnormal development and use of language, and monotonously repetitive behaviours. Autism are usually apparent before 3 years of age may be diagnosed as young as 18 months [2].

Rice estimated that between 1 in 80 and 1 in 240 with an average of 1 in 110 children in the United State have autism [3]. Autism was reported in all racial, ethnic and socioeconomic groups, and is, on average, 4 to 5 times more common in boys than girls. Long and Gurka estimated of current prevalence of children with Autism is just over one per 100, and males are four times more likely to be diagnosed than females [4]. Centers of Disease Control (CDD) showed that there are 1 in 88 children in the United State have autism. Based on the Centers for Control and Prevention in United State, with the incidence of autism spectrum disorder (ASD) increasing to one in 68 U.S. children [5]. Based on the results of the study can be concluded that the increased prevalence of autism is higher.

Individuals who have autism disorder are found with varying degrees of intelligence with average intelligence and above average are considered to have high functioning autism, while autism that has below-average intelligence is called low functioning autism [6]. More students are identified as having
ASD, and thus, a greater focus of research on their progress through the education system takes place [7].

Low functioning autism falls on the more severe end of the autism spectrum. Children diagnosed with this form of autism need more support to complete daily tasks as they struggle to communicate and manage their behaviors. Symptoms are typically identifiable in infancy or early childhood, as those diagnosed will not meet neurodevelopmental benchmarks such as speaking their first words, learning to self-soothe, or forming bonds with family members and other children. Social interactions for children with severe autism can be difficult to near impossible, depending on the child. Some children will hit early milestones and then experience a regression of social skills previously acquired between the ages of three and five. Others will never develop the skills. Because of their limited emotional range and inability to comprehend the emotions of those with whom they interact, these children sometimes appear to lack empathy making it just as difficult for neuron typical children to initiate interactions with them. Inappropriate responses, such as laughing in serious situations or crying in lighthearted moments, or a complete lack of engagement are hallmark signs of low functioning autism. Most children will lean towards a lack of social responsiveness as seen through little to no eye contact, not acknowledging others’ presences (even the parent or caretakers), and little to no smiling. Children with autism generally have a hard time comprehending facial expressions and therefore do not exhibit many in social situations, but this symptom is exaggerated in low functioning children as their faces often remain blank even as they are experiencing pain [8].

Every child deserves an education, and children with low functioning autism are no exception. Some parents prefer to send their children to specialized schools equipped to help children with autism, while others prefer accommodations to be made in an exceptional student education classroom. Individualized Education Plans (IEP) can be made by a school psychiatrist with professional team. The child’s abilities and interests will be evaluated to form a plan that will best cater to educational goals for the child. Support staff are generally available to help the child throughout the day, and many schools offer one-on-one time for the child with a speech therapist, occupational therapist, recreational therapist, psychologist, and psychiatrist [8].

In Indonesia children with autism disorder are enrolled in inclusive schools. Inclusive schools are schools that receive students with special needs belonging to one class with regularly students. The purpose of inclusion schools is to provide opportunities for students with special needs to interact with regularly students so that their disturbances will be lessened. Inclusive schools use the same curriculum as well as non-inclusive school curriculum [9]. Differences in the treatment of learning process for students with special needs is the use of individual education plan (IEP).

Based on the characteristics of low functioning autism students, the low functioning autism student will experience obstacles in the learning process. Obstacles experienced in the form of difficulties in understanding learning materials. Many educators feel unable to adapt their teaching and learning programs to meet the needs or characteristics of autism students, which have implications for their educational success [10]. Students with autism are significantly lower than students without autism on mathematics problem solving skills and daily life mathematics knowledge [11].

Therefore, a research is needed to reveal in depth how the cognition processes of low functioning autism spectrum disorder student works in mathematical problems solving. This research will explore the cognition processes that consists of understanding the problems, developing a plan to solve the problems, completing computations, and checking to ensure the process of mathematics problem solving resulted in a correct answer. The results of this research can be utilized to improve the quality of the learning process, especially low functioning autism student.

2. Research method

2.1. Subject
In determining the subject of research, the researcher conducted a search about the existence of students with autism in locations such as resource centers, inclusive high schools, and therapy centers. From
those students with autism spectrum disorder, researchers identified further classification took place based on whether they were low functioning. Based on the above search, a student with low functioning autism was chosen. The student was diagnosed with autism from three years of age, is a male with an IQ score below 90 and attend high school in Indonesia with exposure to the inclusive education systems. The subject was able to control himself well and not tantrum because he had received treatment during the therapy program. The subject was able to communicate with his friends in the class, although sometimes he was still silent and talking to himself. Based on information from the accompanying teacher, the subject has a high interest in learning. Even though the subject was still unable to understand what was explained by the teacher when in class, the subject still had good self-confidence.

2.2. Ethics/permissions
This research obtained permission from the Minister of Education and Culture and the relevant schools. This research has also received permission from the principal, teachers and parents of student. Pseudonyms have been used to protect the identity of the participants who were free to withdraw from the research without fear or prejudice at any time.

2.3. Setting
The research took place in a high public school, in Surabaya East Java Province in Indonesia. The school was located in a suburb in the second largest city in Indonesia. At the school a certified educator provided support services for students with special need. The school not only accepts autism spectrum disorder students but also accepts a variety of students with special needs, such as down syndrome, hearing impairment, speech impairment, cerebral palsy and other disorders. Some treatments are given for students with special needs in special classes that have been provided with teachers who come from special education. This school is one of the schools that has obtained permission as an inclusive school from the Education Office and is given facilities for students with special needs.

2.4. Design
The research approach was done in a flexible and evolving style in accordance with the circumstances in the field. Adjustments were made to the factors that affect the results of the study. The results of the study can not be generalized, but only infer actual phenomenon in the field according to the research objectives. The approach was categorized as qualitative, while this type of research is descriptive explorative research [12]. The qualitative data on the general form of words was derived from observation, interviews or documents. Qualitative data has advantages compared with quantitative data; for example qualitative data is richer in terms of descriptions and explanations [13].

2.5. Instruments and its validation
In accordance with the type of the research, qualitative research, the main instrument in this reserach was the researchers, while the auxiliary instrument was in the form of mathematical problem test instruments and instrument guided interviews. The material in the problems was developed based on curriculum applicable in high school level. Every problem used would be process by experts through content validation. The validator are two mathematics class teachers and two mathematics specialists from the University. The aim of the validation process was to validate the construction of problems, materials and language in the problems. The mathematical problems test instrument was used to collect data about the cognition process undertaken by the subject in solving mathematical problems based on Polya problem solving procedures. The responses written or disclosed by the subject in each problem-solving step would be used as a guide to analyze the process of cognition conducted by the subject. The researchers also provided the second mathematical problem which is equivalent to the first mathematical problem as a research instrument used for data triangulation. The type of triangulation used in this study is time triangulation. Triangulation was needed to ensure the validity of the data in this study. The researcher also prepared interview guidelines that were used to explore additional data needed in this
study. When the subject is working on the problem, the researchers conducted an interview to find out what the subject is thinking. The picture below is the instrument of this research.

![Triangle Patterns](image)

**Figure 1.** The mathematical problem test instrument.

### 2.6. Data collection and analysis procedures

Data collection on the subject of research was carried out sequentially, one by one according to the steps in solving mathematical problems according to Polya's theory. Data collection was carried out in schools repeatedly until research data were obtained that could answer the problem question in this research. The data collection was done by using task-based interviews with a thinking aloud method. The subject of this study worked on mathematical problems by writing answers on the answer sheet provided and revealing what he was thinking at that time with a loud voice. If the subject did not reveal his thinking processes, the researcher would ask probing open-ended questions to elicit a response. All activities of the subject at the time of solving mathematical problems were recorded with the video recorder. Analysis of the data used the answer sheet of subject, the transcripts from the video recording and interpretations of the subject behaviors while they solve the problems. The data was categorized into four categories, understanding the problems, devising a plan to solve the problems, completing computations, and checking to ensure the process of problem solving resulted in a correct answer [14].

Data analysis was carried out using sequences: (1) classification of data, (2) reduction of data, (3) presentation of data, (4) interpretation of data, and (5) conclusion.

### 3. Results

This study reveals the cognition processes of the subject as he solved the mathematical problems. The cognition processes involved understanding the problems, developing a plan to solve the problems, completing computations, and checking to ensure the process of problem solving resulted in a correct answer [14].

When the researcher gives the mathematics problem sheet, the subject was not looking at the researcher. The subject received the question sheet by looking ahead with blank stare. The subject read the mathematics problem in a rather loud voice. The subject only read part of the mathematics problem sheet. The subject read the mathematics problem again after the researcher asked the subject to continue reading. But the subject stopped reading again even though all the mathematics problem as a whole have not been read. The subject continued reading again after the researcher recalled to read the entire sentence in the mathematics problem. After reading, the researcher asks the subject to understand the mathematical problem. The subject was silent while looking at the mathematics problem sheet. The subject said he understood the mathematical problem after the researcher asked whether the subject understood the problem. This interview transcript represents the description.
Researcher : This is a mathematical problem sheet (offering a mathematical problem sheet to the subject).
Subject : Yes (take the mathematical problem sheet).
Researcher : Can you read it?
Subject : (Reading the question in a rather loud voice, while playing a ballpoint in his hand). I have read it.
Researcher : Please, read all of the problem.
Subject : (Continue to read the mathematical problem). I have read it.
Researcher : Please, you can read it to completion.
Subject : (Continue to read the mathematical problem). I have read it all.
Researcher : Then you can understand the problem.
Subject : (Look at the mathematical the problem sheet while playing a ballpoint in his hand).
Researcher : Have you understand it?
Subject : Yes I have.
Researcher : Are you sure?
Subject : Yes I am.

When the researcher asked the subject to explain the mathematics problem, the subject just smiled and said over and over what the researcher said. The subject has difficulty to understand the mathematics problem even though the information in the problem in chapped into some simple information. The subject was unable to identify which ones were known and which were asked in the problem. This interview transcript represents the description.

Researcher : Now can you tell the contents of the problem using your own sentence?
Subject : (Shut up while looking at the question sheet).
Researcher : You can tell any information in the problem?
Subject : There are level 1, level 2, level 3.
Researcher : At level 1, how many matchstick are there?
Subject : What?
Researcher : How many matches are needed to arrange level 1?
Subject : (Shut up while looking at the question sheet). What?
Researcher : How many matches are needed to arrange level 1?
Subject : (Shut up while looking at the question sheet). I do not understand it.
Researcher : Where is level 1 at the picture?
Subject : This one (point to image of the level 1 of triangle arrangement in the question sheet).
Researcher : Yes, very good. let's count how many matches.
Subject : Three.
Researcher : Yes, very good. How about the level 2? How many matches are needed to arrange level 2?
Subject : (Calculate the number of matchsticks at level 2). One, two, three, four, five, six. Six.
Researcher : Are you sure?
Subject : Yes, I am.
Researcher : Try counting again.
Subject : One, two, three, four, five, six. Yes, that is right.
Researcher : The matchstick is counted.
Subject : (Return to count the matchstick on the level 2 of triangle arrangement). Nine.
Researcher : Ok, very good. How about level 3?
Subject : (Count the number of matchsticks in the level 3 of triangle arrangement by pointing the matchstick using a ballpoint). Seventeen.
Researcher : Are you sure? Try to count again carefully?
Subject : (Count the number of matchsticks in the level 3 of triangle arrangement by pointing the matchstick using a ballpoint). Eighteen.
Researcher : Ok, very good. What else is known in the problem?
Subject : (Shut up while looking at the question sheet).
Researcher : Mention what other information is known in the problem?
Subject : How many matches are needed to arrange level 5 triangles?
Researcher : Is that known or asked in the problem?
Subject : Known.
Researcher : Are you sure that's what is known in the problem?
Subject : Yes, I am.

To help understand the problem, the researcher gave a realistic media, the subject took the media and seemed interested in the media but the media was unable to help the subject in understanding the problem. Although the subject seemed confused in using the media, but the subjects did not have the initiative to ask the researcher. The subject is not able to arrange the triangle level correctly because he does not understand the pattern, even though he uses media. The level arrangement of the triangle made by the subject can be seen from the following picture.

Figure 2. The arrangement of the 1st, 2nd, 3rd and 4th level triangles made by the subject.

The subject cannot find a pattern from the arrangement of triangles at level 1, level 2 and level 3. So the subject has difficulty drawing and arranging the next level triangle. Although using media the subject has difficulty in compiling the next level. The subject is only able to understand if the level is higher then there are also many matchsticks and the higher the arrangement. This interview transcript represents the description.

Researcher : What's the difference between level 1 and other levels?
Subject : I do not understand.
Researcher : You can observe the picture of the level of triangle arrangement in the sheet. After that you can find the difference between level one and other levels.
Subject : (Shut up while looking at the picture of triangle arrangement).
Researcher : What is the difference between level 1 and level 2?
Subject : The number of matchsticks at level 2 is more than level 1.
Researcher : Level 2 has a matchstick more than level 1. Can you look for the difference again? Try to pay attention to the arrangement.
Subject : Level 2 is higher than level 1.
Researcher : Ok,very good. Next, what is the difference between level 2 and level 3?
Subject : Level 3 matchstick is more than level 2.
Researcher : Ok good. Besides that what is the difference?
Subject : Level 3 is higher than level 2.

The subject was unable to remember that he had studied the material related to this problem. The subject is not able to determine the important information in the problem. The subject is more interested in seeing the image in the problem than looking at the sentence in the problem. Even so it cannot help the subject to find the pattern of the triangle arrangement. The subject said he could not draw the next level triangle arrangement because only three levels were known in the problem.

Researcher : Do you still remember this problem related to what material?
Subject : No. I don’t remember.
Researcher : Have you ever worked on a problem similar to this problem?
Subject : No. I don’t remember.
Researcher : So to make the next triangle pattern, which information is the most important to use?
Subject : Number of triangle level 5.
Researcher : Are you more interested in seeing the sentence in that question or see the picture?
Subject : The picture.
Researcher : Why are you more interested in seeing the picture??
Subject : Because it's the level.
Researcher : From that picture, it's not enough to make the next level triangle?
Subject : Yes, enough.
Researcher : Why is enough?
Subject : We can draw 3 levels.
Researcher : From the three levels, you can draw the next level?
Subject : No, I can not.
Researcher : Why can't you draw it?
Subject : Yes, just draw 3 levels just like the picture on the problem.

The subject was not able to make a settlement plan because the subject did not understand the problem. The subject was unable to compile the 4th level triangle because the subject was unable to find the pattern in the triangle arrangement. Realistic media in the form of matchsticks provided by researchers cannot help the subject to find the pattern. Several times the subject smiled and bounced back the questions conveyed by researcher. When the researcher asked the subject to try to solve the problem, the subject tried to answer the researcher's question even though the subject’s answer is irrelevant to the problem given by the researcher. Several times the subject spoke and muttered to himself with a vague sentence.

4. Discussion and conclusion
At the stage of understanding the problem, subject was not able to understand it well even though the researcher provides help by breaking the problem into some simple information and explaining it to the subject. When researcher questions, subject not to look at researchers. Characteristics of autism appear and tend to look very dominant. This is in the form of nonverbal behaviours such as eye contact, facial expressions, gestures and gestures for social interaction. This study show that the low functioning autism student has an inability to interact and communicate. The characteristics accord with the characteristics of low functioning autism described by the American psychological association [15].

The subject is not able to correctly represent the problem. This is very different from previous research conducted by Fauziyah, Le Lant, Budayasa, and Juniati with high functioning autism spectrum disorder student subject [16]. Subjects with high functioning autism spectrum disorder able to represent problems with 3 different representations, namely in the form of Pictorial, verbal language, and symbol.
The subject in this study were unable to find patterns from level 1, 2 and 3 triangles. This also was
different from previous studies by Fauziyah et al with subject with high functioning autism spectrum
disorder [16], Subject with high functioning autism spectrum disorder able to find patterns and able to
compile the next level triangles, even able to find the formula for the term n.

Since the subject was incapable of understanding the problem, the subject cannot complete the next
step, developing a plan to solve the problems, completing computations, and checking the process of
problem solving. A thorough lack of spoken language is not accompanied by an attempt to compensate
by the use of gestures or facial expressions as an alternative way of communicating. The low functioning
autism student does not have the ability to start or continue the conversation with others even with simple
conversations. The subject used repetitive language or stereotypical or idiosyncratic. The characteristics
accord with the research undertaken by Boucher, Bigham, Mayes, and Muskett [17].

In this study it can be concluded that the subject has difficulty in solving mathematical problems.
The subject is incapable of preparing a settlement plan. The subject was not able to make a count to
solve the problem despite being assisted with the media. The subject did not re-check the problem-
solving process because it was unable to provide the relevant response of any questions that existed in
the problem.

The stage of understanding a problem is very important to be able to do the next stage. A student
who is unable to understand the problem will certainly not be able to plan a solution well. If a student
cannot plan a solution well, surely he will not be able to solve the problem correctly. To understanding
a mathematical word problem need the ability to understand sentence by sentence. The ability to
understand language has a significant influence in understanding a mathematical word problem. Thus it
is recommended for teachers to give great attention to the stage of understanding problems in
mathematics learning. For children who have low intelligence more focused on the stage of
understanding the problem first before the next stage.

Acknowledgments
We would like to acknowledge the support of Universitas Negeri Surabaya and Universitas
Muhammadiyah Gresik, East Java, Indonesia. We appreciate the participation of student, teachers, and
parents in this research.

Declaration of conflicting interests
The authors declared no potential conflicts of interest with respect to the research, authorship, and/or
publication of this article.

Funding
This study was supported with funding from Ministry of Research, Technology and Higher Education
(kemristekdikti) based at Jakarta, Indonesia in the Dissertation Research for Doctorate Program.

References
[1] Adams M P 2011 Explaining the Theory of Mind Deficit in Autism Spectrum Disorder (USA: Springer Science and Business Media)
[2] Holaday B 2012 History of Autism (USA: The South Carolina Nurse)
[3] Rice 2009 Prevalence of Autism Spectrum Disorder Journal of Autism and Developmental Disorder 1-20
[4] Long C and Gurka M 2011 Cognitive Skills of Young Children with and without Autism Spectrum Disorder Using the BSID-III Journal of Autism Research and Treatment
[5] Sainato D M 2015 Comprehensive Inclusion Program for Kindergarten Children With Autism Spectrum Disorder Journal of Early Intervention 208-225
[6] Chiang H M and Lin Y H 2007 Mathematical ability of students with Asperger syndrome and high-functioning autism Autism 547-556
[7] Fordyce T A, Leonhard M J and Chang E T 2017 A critical review of developmental exposure to particulate matter, autism spectrum disorder, and attention deficit hyperactivity disorder *Journal of Environmental Science and Health* 1-31

[8] Hobbs K G 2018 Low Functioning Autism – What Sets it Apart *Autism Parenting* 1-8

[9] Minister of National Education t R o I 2009 *Inclusive Education* (Jakarta: Minister of National Education of the Republic of Indonesia)

[10] Fleury V P, Hedges S, Hume K, Browder D M, Thompson J L, Fallin K, . . . Vaughn S 2014 Addressing the Academic Needs of Adolescents With Autism Spectrum Disorder in Secondary Education *Remedial and Special Education* 68-79

[11] Bae Y S, Chiang H-M and Hickson L 2015 Mathematical Word Problem Solving Ability of Children with Autism Spectrum Disorder and their Typically Developing Peers *Journal of Autism Development Disorder* 2200-2208

[12] Merriam S B 2009 *Qualitative Research : A Guide to Design and Implementation* (Chichester, United Kingdom: John Wiley and Sons Ltd.)

[13] Huberman A M, Miles M B and Saldana J M 2013 *Qualitative Data Analysis* (United States: SAGE Publications Inc.)

[14] Polya G 1948 *How to Solve it, A New Aspect of Mathematical Method* (New Jersey: Princeton University Press)

[15] APA 2013 *Diagnostic and Statistical Manual of Mental Disorders* (American Psychiatric Publishing)

[16] Fauziyah N, Le Lant C, Budayasa I K and Juniati D 2019 Cognition Processes of Students with High Functioning Autism Spectrum Disorder in Solving Mathematical Problems *International Journal of Instruction* 12 (1) 457-478

[17] Boucher J, Bigham S, Mayes A and Muskett T 2007 Recognition and Language in Low Functioning Autism *Journal of autism and developmental disorders*