Profile of Higher Order Thinking Skill Based on Mathematical Connection Levels in Industrial Revolution 4.0

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Abstract. The 4.0 industrial revolution created increasingly fierce competition in various fields. With HOTS, everyone is expected to be more critical and creative in facing problems. In addition to the 4.0 industrial revolution occurred in all fields so that the necessary relationship between one field with another field, the ability of mathematical connections is one of one's abilities in looking for the relationship between mathematics with other scientific fields. This research aims to determine students' higher order thinking skills based on their level of mathematical connection ability in the face of the industrial revolution 4.0. The method used in this research is a qualitative research method using the Miles and Huberman model which includes data reduction, data presentation, and drawing conclusions. The subjects of this study were three students with high, medium and low mathematical connection skills. The data collection process used is tests, observations, and interviews. The results of this study indicate that students with high mathematical connection ability are able to reach all stages of higher level thinking in mathematical problem solving. Students with moderate mathematical connection skills fulfill only a few stages of higher-order thinking in mathematical problem solving. While students with low mathematical connection skills only reach the first stage of thinking at a high level in solving mathematical problems.

Keywords: HOTS, Mathematical Connection, Industrial Revolution 4.0

1 Introduction

At present science and technology are developing so rapidly in line with the industrial revolution 4.0. To deal with this, reliable human resources are needed, they are able to compete globally. Education has a very important role to increase the existing human resources. Because education can create a superior and competitive generation in an effort to face the challenges that exist in the future. Mathematics education in the schools aims to develop student reasoning, so students can become individuals who are trained in their way of thinking, consistent, active, creative, independent and have the ability to solve problems. Human thinking abilities can be classified into two categories; lower order thinking skills (LOTS) and higher order thinking skills (HOTS) [1]. It is very important to be able to create a creative and innovative generation in the effort to face the industrial revolution 4.0 in the future.

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In fact the quality of mathematics education in Indonesia is still relatively low, this can be seen from the results of the Trend in International Mathematics and Science Study (TIMSS) survey that showing the latest results in 2011 Indonesian students Mathematics Literacy in TIMSS was only able to rank 38 out of 42 countries with a score of 386 and is still below the international average score of 500. In addition to the latest Programe for International Student Assessment (PISA) tests in the year 2015 shows that Indonesia has only been ranked 69 out of 76 countries and is still at the lowest level. The PISA report shows that the thinking ability of Indonesian students in mathematics is currently very low. This fact also shows the thinking ability of Indonesian students especially in mathematics, receives less attention. This happens becauseof students are less trained in solving higher order thinking skillsand still using low order thinking skills while the test questions used by TIMSS and PISA are higher order thinking skills category questions [2].

The ability to think at a higher level or in a foreign language is often referred as Higher Order Thinking Skills (HOTS) is to do a broad thinking process to solve problems [3]. Thinking skills that can be categorized as higher order thinking skills are critical thinking, creative thinking, problem solving, metacognition and conclusion drawing [4]. In the cognitive realm of Bloom's Taxonomy in both the original and revised versions there are three levels that are classified as Higher Order Thinking Skills , namely Analyzing, Evaluating and Creating in revised Bloom Taxonomies [1]. High order thinking skills is a process of thinking with a higher level than simply remembering the facts or retelling what was heard to others [5]. The characteristics of higher order thinking skills are included in the ability to think critically and think creatively [6]. Characteristics of High Order Thinking Skills (HOTS) is a non-algorithmic, complex and produce some solutions, requiring the application on several criteria, regulation, and often lead to uncertainty [7]. While other opinions say that the characteristics of High Order Thinking Skills (HOTS) in science education are oriented to formulating questions about problems, planning ways of solving, making and justifying arguments, identifying reliable sources of information [8].The development of instruments related to HOTS is very important to do in mathematics learning because the assessment of learning achievements conducted globally is now starting to change from traditional learning using Low Order Thinking Skills (LOTS) to High Order Thinking Skills (HOTS) [9]. Indicators of Higher Order Thinking Skills (HOTS) in this research are the last three levels in the revised Bloom taxonomy, namelyanalyze, evaluating, and create.

Analyze. This level is divided into three, including: (Differentiating) differentiating relevant parts from irrelevant parts or differentiating important parts from parts that are not important in a particular material. (Organizing) which determines how an element fits or functions in an organization. (Attributing) which determines the point of view, value or purpose of a material presented.

Evaluating. This level is divided into two, including: (Checking) which is detecting errors or errors in a process. (Critiquing) which is detecting the accuracy of a procedure for certain problems.

Create.This level is divided into three, including: (Generating) which can mention alternative hypotheses based on a criterion.(Planning) which is creating a procedure for doing tasks. (Producing) which is creating a product [1].

The several aspects needed in higherorder thinking thinking skills, a person needs good mathematical connection skills in order to support the higher-order thinking skills. In general, mathematical connections are classified into two, namely modeling connections and mathematical connections. Connection modeling is the relationship between a problem that

arises in the real world or in other disciplines with mathematical representation, while the mathematical connection is the relationship between a concept and other concepts in mathematics to be able to solve mathematical problems [10]. The ability of mathematical connections is the ability to connect conceptual and procedural knowledge, use mathematics on other topics, use mathematics in life activities, know connections between topics in mathematics [11]. Mathematics is not a separate collection of topics, although in reality mathematics is taught in different topics or chapters, but these topics are prerequisites that can be used as a basis for understanding the next topic [12]. Therefore mathematical connections have a vital role in learning mathematics. Moreover, the connection with HOTS where the problems that arise are high-level problems often the problems that arise do not lead to mathematical representation in accordance with the characteristics of HOTS itself, which is unpredictable, so it requires the ability of mathematical connections to be able to understand the problem well, look for the relationship between the problem with representation mathematical logic, then look for mathematical concepts related to problems that can be used to develop appropriate problem solving strategies. Mathematical connections are used to help students expand their perspectives, to see mathematics as something whole rather than as a series of separate topics. If students can connect mathematical concepts, their understanding will be deeper and more lasting [13]. To find out how far students' mathematical connection skills can be seen in mathematical problem solving, especially HOTS type problem solving. With HOTS type problem solving students can further develop and build ideas, practice integrating the concepts, theorems and skills they have.

The aim of this study is to describe students higher order thinking skills in mathematical problem solving based on each level of mathematical connection ability. By knowing the higher order thinking skills at each level of mathematical connection ability is expected to be a reference for educators to determine what actions need to be taken to improve students' high level thinking skills in solving mathematical problems. With good higher order thinking skills process, it is hoped that students will be able to face the ongoing competitive industrial revolution 4.0.

2 Methods

The type of research is a descriptive qualitative, the researcher conducts the analysis only to the extent of describing higher order thinking skillsprocess to be examined by presenting the facts systematically. The purpose of this research is to describe higher order thinking skills processes in solving mathematical problems based on each level of mathematical connection ability. The subjects in this study were students of SMP Negeri 4 Purwokerto. Taking the subjects in this research using puposive sampling techniques conducted selectively using certain considerations. The method used in this research is a qualitative research method using the Miles and Huberman model which includes data collection, data reduction, data presentation, and drawing conclusions. The data of this research are in the form of facts that are presented in accordance with the facts that occur in the study. The subjects used are based on the criteria of students who meet the indicators of mathematical connection ability after conducting a mathematical connection ability test. From these tests 3 students were selected with each of the three categories (S1) for high, Medium (S2) and low (S3). The data collection process used is test, observation, and unstructured interviews.

3 Results and Discussion

A high-level thinking ability test in mathematical problem solving is given to three selected subjects for 30 minutes. Based on the results of tests and interviews of the three subjectsobtained the following results. Based on the results of tests of higher-order thinking ability in mathematical problem solving carried out by S1, it can be seen that S1 masters every stage in the level thinking process. This can be seen from the results of student answers.

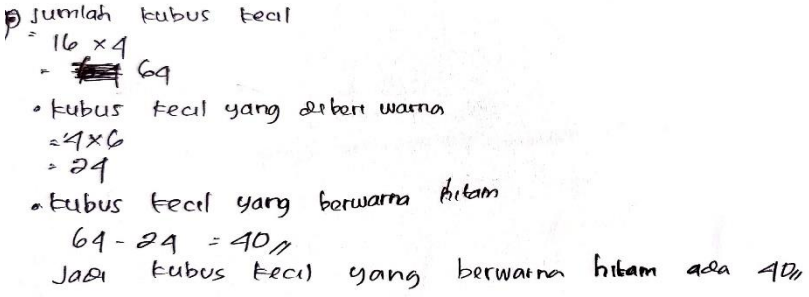


Fig. 1. (S1) Answer Sheet Question Number 1

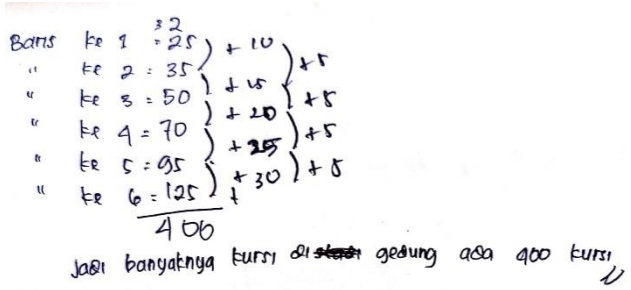


Fig. 2. (S1) Answer Sheet Question Number 2

From Fig 1. & Fig 2. (S1) can be seen analyzing phase the students well. Phase analyzing and organizing diferrenting level achieved by students by mentioning what is known and necessary in the matter to completion. On question number 1 (S1) Explaining that there is a rubik composed of small cubes in it with each side consisting of 4 cubes, and each side there are 4 colorful cubes surrounded by black cubes, students also mentioned that what should be sought is the number of black cubes in the rubik. In question number 2 students mentioned that there are six rows of seats which each line has a different number, (S1) states that in question is the total number of seats. Attributing this level at this stage of analyzes performed (S1) with a good case can be seen from the results of the students' answers to write correctly the values referred to in the matter. The Create stage (S1) is done by finding ways that can be done in solving the problem (generating) in this case the student says that in solving problem number 1, what must be done is to count the total number of cubes and count the number of colored blocks so that they can find the number of other cubes. The planning level (S1) compiles a completion step that the number of black cubes can be sought by subtracting the total number of cubes minus the colorful cubes. The level of producing is done by operating the calculation of the steps that have been done before so as to obtain the results of the answers. In question number 2 the generating level is done by observing the structure/pattern of the rows in the problem. The level of planning is carried out by determining the method will be used that is by adding up the number of corrections per line up to the sixth row. The

level of producing is done by adding up each row of chairs so that the total number of chairs is 400 chairs.The evaluation phase is done by (S1) by looking at the structure of the questions to see the suitability of what is known in the problem with what is asked in the problem. In the question number 1 the level of checking is done by seeing whether all the calculation operations performed are correct. Then critiquing is done by looking at the suitability of the procedures performed in working on the problems. In question number 2 checking is done by looking again at whether the pattern specified is correct and checking the calculation process is correct. The level of critiquing is done by looking at the suitability of the procedures performed with the results of the answers.

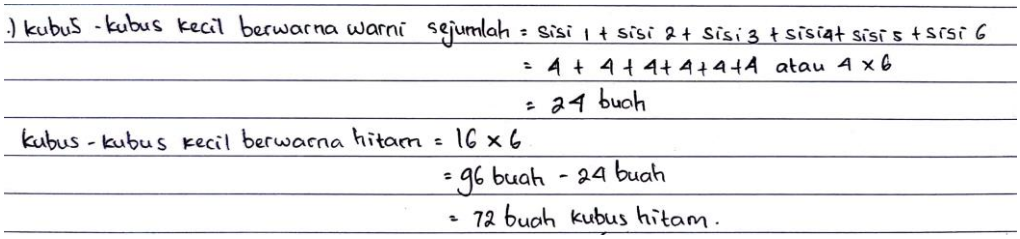


Fig. 3. (S2) Answer Sheet Question Number 1

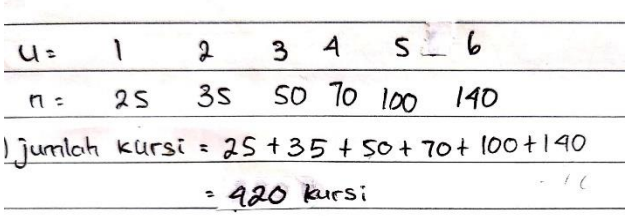
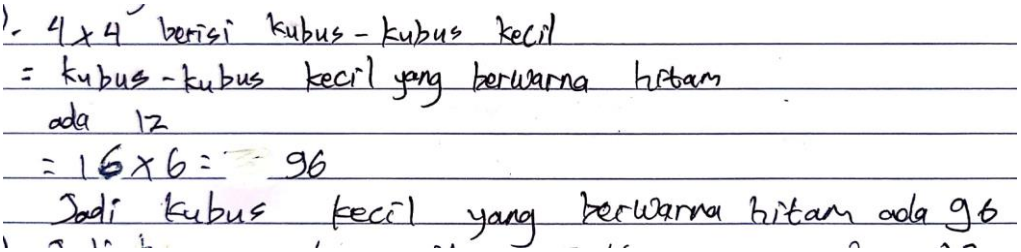


Fig. 4. (S2) Answer Sheet Question Number 1

From Fig 3. & Fig 4. (S2) can be seen analyzing phase the students well. The stage of analyzing the level of differentiation and organizing is achieved by stating what students know and need in the problem to solve. In question number 1 (S2) explaining that there is a rubik composed of small cubes inside with each side consisting of 4 cubes, and each side there are 4 colorful cubes surrounded by black cubes, students also mentioned that what to look for is the number of black cubes in the rubik. In question number 2 students mentioned that there were 6 rows of chairs where each row had a different number, (S2) said that the number asked was the total number of seats. The level of attributing at the stage of analyzing the (S2) done well this can be seen from the results of student answers that can write correctly the values referred to in the problem. The Create phase done by finding a way to do in solving problems (generating) in this case (S2) mention that in the resolution about the question number 1 thing to do is count the number of cubes colorful and calculate the whole cube on a Rubik so as to seek the number black cube by calculating the difference. Planning level is done by setting the pace of completion that the number of black cube can be found by subtracting the amount whole cube is reduced with colorful cube but at the time of determining the total number of the Rubik cube seen from the answers that (S2) does not understand the concept of volume of the cube. Producing level is done by operating the calculation of measures tel a h done earlier so as to obtain the results of the answers. In question number 2 the generating level is done by examining the structure/pattern of the existing sequence in the problem but in this case (S2) has difficulty determining the pattern of the sequence contained in the problem . The level of planning done by (S2) to determine how that will be used is by summing the number of chairs

each row to row six. Producing level is done by adding up the rows of seats in order to obtain the total number of seats is 400 seats.Phase evaluate performed by (S2) to see the structure of matter to look at the suitability of what is known in terms with what is asked in the problem. In question number 1, the checking level is performed by seeing whether all the calculation operations performed are correct. Then critiquing is done by looking at the suitability of the procedures performed in working on the problems. In question number 2 checking is not done, so that there is an error when determining the pattern of rows in the problem . The level of



critiquing is done by looking at the suitability of the procedures performed with the results of the answers.

Fig. 5. (S3) Answer Sheet Question Number 1

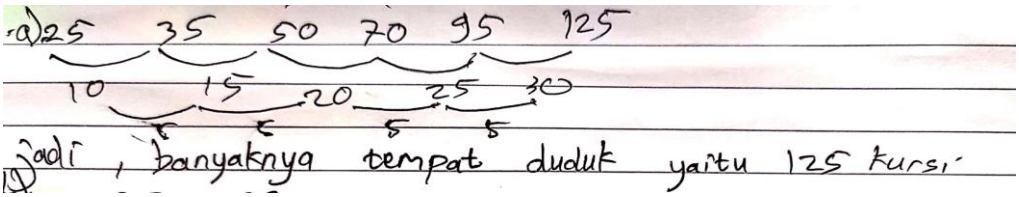


Fig. 6. (S3) Answer Sheet Question Number 2

From Fig 5 & Fig 6. it can be seen that (S3) cannot analyze properly. At the stage of analyzing the level of differentiation , organizing and attributing (S3) is not able to mention what is needed in the matter to do the settlement. In question number 1, during the (S3) interview only mentioning 12 black cubes , the students said that what to look for was the number of black cubes in the rubik. In question number 2 students mentioned that there are 6 rows of chairs where each row has a different number, (S3) states that what is asked is the total number of seats.The create stage is done by (S3) by looking for ways that can be done in solving problems (generating) in this case (S2) states that in solving questions number 1 (S3) tries to count the total number of cubes in rubics but with the wrong concept. (S3) has no completion plan so the level of planning at the creative stage is not reached. The level of producing is not carried out by (S3). In problem number 2 the level of generating is done by looking at the structure/pattern of the existing lines in the problem but in this case (S3) is able to determine the pattern of the sequence contained in the problem. The planning level is done by (S3) by looking at the number of seats in the sixth row . The level of producing is not carried out by (S3). The evaluation phase is not carried out by (S3). (S3) does not re-examine the work done in solving problems. It is known at the time of the (S3) interview that he did not re-examine his work because he felt the questions given were too difficult.

At the moment higher order thinking skills (HOTS) are needed by every student. Students are not only required to be able to apply what they have learned, but students must

also be able to analyze, evaluate and synthesize the knowledge they have to solve problems in daily life [14]. Based on the results that have been described, it can be seen that students with moderate and low mathematical connection abilities have not been able to do hots well. Therefore students need to be trained to become familiar with higher order thinking skills (HOTS). Because HOTS can play an important role in understanding mathematics and solving problems that will be used to face the competition of the industrial revolution 4.0 [15].

Some ways that can be done to increase hots are through training the teacher on the implementation of hots in mathematics learning. Based on the research, it was found that knowledge training and the application of higher order thinking skills to each teacher need to be carried out continuously to deal with any changes and progress in applying higher order thinking skills in mathematics learning, considering that at this time these abilities are very necessary in learning [16]. Another step that can be done is to get used to hots questions in learning. The more HOTS content in a textbook, the more likely HOTS to be trained and taught to students [14]. Furthermore, teachers can use scientific learning models that refer to hots. The learning method with inquiry has a significant influence on the development of HOTS among study participants. Also, students expressed positive attitudes, both emotionally and cognitively as a result of the intervention [17]. E-learning can also be applied to increase higher order thinking skills where in the industrial revolution 4.0 all fields are carried out with computerization so this learning model is needs to be applied in learning [18].

In addition, it can be seen that the ability of mathematical connections affects hots, so it is important for teachers to improve students' mathematical connection skills so that hots can be done well. Mathematical connection is a skill that must be built and learned because with good mathematical connection ability will help students to be able to know the relationship of various concepts in mathematics and to apply mathematics in everyday life [19].Based on the results it can be seen that there is a relationship between higher order thinking skills and students' mathematical connection abilities, students with high mathematical connection abilities have better higher order thinking skills, therefore teachers need to improve students' mathematical connection abilities one way that can be done is to use learning models problem based learning.problem-based learning can be used as an alternative to improve mathematical connecting ability [20].

4 Conclusion

Based on the results of the analysis it can be concluded thatthere is a relationship between higher order thinking skills and students' mathematical connection abilities, students with high mathematical connection abilities have better higher order thinking skills.(S1) students with high mathematical connection abilities are able to fulfill every stage in the high-level thinking process that is analyzing (differenting, organizing, and attributing), create (generating, planning, producing), and evaluating (checking, critiquing). (S2) students with medium mathematical connection skills are currently only fulfill a number of stages in the higher level thinking process, namely analyzing (differenting, organizing and attributing) create (producing) and evaluating (critiquing). (S3) students with low mathematical connection capabilities only reach the stage of analyzing (differenting) in the process of highher order thinking skills.

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