Analysis of The Difficulty of VIII\textsuperscript{th} Grade Junior High School Students in Circle Material Reviewed from The Mathematics Connection Ability

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Abstract. This study aims to analyze the difficulty of VIIIth grade junior high school students in circle material reviewed from mathematical connection ability. The method used in this research is descriptive qualitative with a case study approach. The subjects in this study were 23 eight grade in one of the junior high schools in Temanggung. Data collection is done by tests and interviews. The instrument used in this study are 3 questions about the material related to the Circle and interview guide to know where the students’ difficulties are. The results of data analysis showed students varied mathematical connection skills; some students belong to the high category while others are in the medium or low category. However, student’s ability to connect inter-mathematical concepts and apply mathematical concepts in solving daily problems are in the low category with 43.47% and 53.26%. The low mathematical connection ability of students is indicated by the low percentage of students who give correct answers, the low percentage on each indicator of mathematical connections, and errors made by students. Mistakes made by students show the difficulties experienced by students. The difficulty that is generally expressed by students is the difficulty of understanding the problem and the difficulty of determining the formula or theorem used to solve the problem.

1. Introduction

Education is an important basis for the progress of a nation because through education we can see the development of human resources and the management of natural resources. Education is an important aspect to improve the economy of a country [1-3]. Based on these facts, the Indonesian government has been working to improve the quality of education in Indonesia. Education quality improvement can be done through several efforts, one of them is improving the quality of the teacher, complete educational facilities and infrastructure, increase the allocation of education funds and the implementation of continuous education evaluations. Government efforts to improve the quality of education in Indonesia change the paradigm and old mindset about education. Education cannot be seen only as a 'transfer of knowledge', but more than that, education must be understood as a way to prepare students to face many challenges in real life [4]. Shute & Becker [5] explained that in facing the challenges of the current era,
humans are required to have collaborative abilities, think critically and creatively and be able to communicate effectively.

Organizations that focus on developing current learning namely the Partnership for 21st Century Skills [6] reveal that skills that must be possessed by humans to improve their economy, workability and readiness as citizens are, 1) critical thinking and self-evaluation; 2) solving complex, multidisciplinary, and open-minded problems; 3) creative; 4) communicate and collaborate with people across cultures, geographies and languages; and 5) utilizing innovative knowledge, information and opportunities.

Based on the opinions of Partnership for 21st Century Skills organization that is engaged in ability development to face the times in 21st centuries, this is in accordance with the statement National Council Teacher of Mathematics [7] which states the general purpose of learning mathematics is to develop the ability of students in mathematical communication, mathematical reasoning, mathematical problem solving, mathematical connections, and mathematical representation. Based on the learning purpose formulated by NCTM, it is seen that the purpose of implementing mathematics learning is to develop effective and mathematical abilities. Mathematical abilities include problem-solving ability, reasoning, mathematical connection, representation, and mathematical communication.

Mathematics school has an important role for students to reach the standard of mathematical abilities. The material in mathematics learning consists of many things, both related to everyday life, related to other subjects, as well as related to topics in mathematics. The ability to solve mathematical problems related to these three things is known as mathematical connection skills [7] Linto, Elniati, & Rizal [8] explained that mathematical connection ability is the ability to solve mathematical problems related to previous material. Furthermore, Kennedy Tipps & Johnson [9] stated that mathematical connections are abilities that direct students and teachers to find mathematics related to everyday life, associating between mathematical concepts and topics.

According to Sugiman [10], mathematical connection ability is a strategic ability that becomes a mathematics learning goal. Mathematical connection ability is an important thing but students who master mathematical concepts are not smart by themselves in connecting mathematics [10]. Without a mathematical connection, students should learn and remember too many separate concepts and mathematical procedures [7]. The idea of mathematical connections has been examined by W.A. Brownell since 1930, but at that time the idea of mathematical connections was limited to arithmetic [11]. Lembke and Reys [11] said that in research found that students are often able to make a list of mathematical concepts related to real problems, but only a few students were able to explain why the concept was used in the application. This shows that many students are good at solving mathematical problems but not all understand how the relationship between concepts.

The importance of connections in mathematics learning has not been balanced by the mathematical connection abilities possessed by the student. Basically, the student’s mathematical connection ability is still low, this can be seen from the OECD report regarding the results of the PISA 2009 relating to student’s ability to solve questions that require a mathematical connection process, only 5.4% or about 95% of students participating in the activity have not been able to associate problems with concepts/principles, associate with other fields of study, or with daily life [12].

To improve student’s mathematical connection skills, we need to know what is the problem of students in solving problems related to mathematical connections. It is important to know the aspects of the mathematical connection skills that make it difficult for students. So, the cause can be shown and it is expected to get a solution. The aim of this study is to analysis the mathematical connection ability of grade VIIIth students on Circle material.

2. Method
This research is a qualitative study with a case study approach. The case study design is used to obtain an in-depth understanding of the situation and meaning for those involved in the form of descriptive, holistic and intensive analysis. The cases studied are limited by time and activity, the researcher collects information completely using various procedures for collecting data based on the specified time. The
selection of research subjects in this study was carried out intentionally (purposeful) or not randomly to collect the desired data. The subjects of this study were 23 students of grade VIII at one of the Junior High Schools in Temanggung Regency. The process of implementing this study follows the process of case study research according to Yin [13] as follows: (1) define and design research, researchers conduct a study of the theories development or concepts to determine cases and design protocols for data collection; (2) preparing, collecting, and analyzing data, researchers prepare, collect and analyze data based on research protocols that have been previously designed; (3) analyze and conclude, in a single case, the results of the study are used to check back on the concepts or theories that have been built in the first stage of the study.

Data was collected using essay tests and short interviews to know where the students’ difficulties are in which the subjects of the study were asked to write down the steps of their answers in solving the problem. In the interview, the students were asked about the steps they used to solve the given problem and where did they find difficulties in solving it. The test is given consists of 3 questions. These three questions were developed to measure mathematical connection skills which included aspects: (1) connections between topics in mathematics that link material in a particular topic to material in other topics, (2) connections between mathematics material in daily life, (3) connections between mathematics material with other science fields. The indicator of mathematical connection in this research is applying the relationship between concepts in mathematics and applying mathematics concepts to solve the real problem. These two indicators are intended to measure aspects 1 and 2, while the third aspect is indicated by giving questions that link mathematics to other science fields. The language originally used was Bahasa, but the researcher translated it into English for the convenience of the readers. By using student responses, the researcher will classify student’s mathematical connection abilities and identify students’ difficulties in solving problems related to mathematical connections. Criteria for student’s mathematical connection ability is done by calculating the test results score of mathematical connection ability. Then it is changed to the percentage of learning success rate, furthermore, the category of learning success rates is carried out to determine the level of student’s mathematical connection abilities. The category of student learning success rates is a five-scale categorization based on modifications from Suharsimi Arikunto [14] described in Table 1 below.

| Range of Score Mathematical Connection Ability Tests | Category   |
|------------------------------------------------------|------------|
| 84 < skor ≤ 100                                       | Very High  |
| 69 < skor ≤ 84                                        | High       |
| 59 < skor ≤ 69                                        | Enough     |
| 44 < skor ≤ 59                                        | Low        |
| 0 < skor ≤ 44                                         | Very Low   |

Identification of student difficulties types observed from mistakes made by students in answering test items. To maintain the credibility of the data obtained, the test was carried out with the format of the test exercise [4]. Precisely, it is done as the final test of the material and the results are used by their teacher as a component for the semester assessment. By doing this, students do the best to answer the test and the answers they give reflect their true abilities. To prevent students from cheating, researchers asked the teacher for help to supervise the exam. To maintain objectivity while examining and analyzing student answers, researchers ignored student identity, gender, and abilities.
3. Result and Discussion

The test questions in this research consisted of three description questions given to 23 students and worked within 40 minutes. The indicator of mathematical connection in this study consists of two indicators. Indicator 1 applies the relationship between concepts in mathematics. Indicator 2 applies mathematical concepts to solve real problems. Then the data is processed and analyzed based on the assessment rubric. The average test results in this study were 53.8. The results of tests on students mathematical connection skills can be seen in Table 2 below.

| Indicator     | Total Score | Percentage(%) | Category |
|---------------|-------------|---------------|----------|
| Indicator 1   | 150         | 43.47         | Low      |
| Indicator 2   | 98          | 53.26         | Low      |

Based on Table 2, it can be seen that student’s mathematical connection ability in the indicator of applying the relationship between concepts or topics in mathematics is classified as low with a score of 150 or 43.47% of the total score of 345. If the percentage was converted into a score produces an average score of 43.47 so that it falls into the low category. While the indicators applying mathematical concepts to solve real problems are classified as low with a score of 98 or 53.26% from a total score of 184. If the percentage was converted into a score produces an average score of 53.26 so that it falls into the low category.

1. Student Mathematical Connection Ability according to Indicator 1

The first indicator of mathematical connection ability is applying relationships between concepts in mathematics. This ability is seen from the accuracy of students in using the interrelationships between concepts in mathematics to answer what is asked in the question. The following are presented bar charts resulting from the categorization of student’s mathematical connection abilities according to indicator 1.

Based on diagram 1, it can be seen that students' mathematical connection ability in applying the relationship between concepts in mathematics is in a very low category of seven students or...
30% of 23 students, in the low and enough categories each of them is 6 students or 26% of 23 students, in the high category as many as 3 students or by 13% of 23 students, and in the very high category there was only one student.

2. **Student Mathematical Connection Ability according to Indicator 2**

The second indicator of mathematical connection ability is applying mathematical concepts to solve real problems. This ability is seen from the ability of students to modeling real-world problems into mathematical problems and student’s ability to use concepts in circle material to solve problems related to everyday life. The following are presented bar charts resulting from the categorization of students' mathematical connection abilities according to indicator 2.

![Diagram 2. Categories of Mathematical Connection Ability in Applying Relations Between Concepts in Mathematics](image)

**Diagram 2. Categories of Mathematical Connection Ability in Applying Relations Between Concepts in Mathematics**

Based on Diagram 2, it can be seen that students mathematical connection ability in applying deep mathematical concepts are in a very low category of 4 students or 17% of 23 students, in the low category as many as 7 students or 30% of 23 students, enough categories are 2 students or by 8% of 23 students, in the high category as many as 4 students or by 17% of 23 students, and in the very high category there were only 6 students or 26% of 23 students.

**Identification of Students Difficulties in Solving Mathematical Connection Problems**

Identification of students’ difficulties in solving mathematical connection problems seen from the mistakes made by students in answering questions. The following is the data on the number of students who answered the questions and did not answer the questions, and the number of correct answers, the data is presented in the table below.

| Question 1 | Question 2 | Question 3 | Average |
|------------|------------|------------|---------|
| n | % | n | % | n | % | n |
| Answer | 23 | 100 | 23 | 100 | 10 | 43 | 82 |
| No Answer | 0 | 0 | 0 | 0 | 13 | 57 | 18 |
| Correct Answer | 13 | 57 | 0 | 0 | 0 | 0 | 18 |

**Table 3. Percentage of Students that Answering Questions, Not Answering Questions and Correct Answers**
Based on the table above, it can be seen that the average percentage of correct student answers is 18% of the three questions given to 23 students. That is, the percentage of students answered correctly was lower than the average number of students answered correctly. The difficulties of students in this study can be seen from the mistakes made by students on each question.

**The Mistakes Made by Students on Question Number 1**

The number 1 question is shown as follows.

1. Mr. Sugi has a backyard with a square shape and length of 14 m. There will be made a pond (not shaded) and partially planted with ornamental grass (shaded) according to the picture below.

   ![Figure 1: Question number 1](image)

   a. What is the area of the yard planted with grass? Do you need to know the area of a circle to find the area planted with grass? Why?
   
   b. If the cost of purchasing grass seeds and fertilizer is IDR 50,000.00 / m² and the cost of a lawn mower is IDR 250,000. If Mr. Sugi has a budget of IDR 2,500,000.00 for planting grass, does Mr. Sugi still have the remaining money after the yard is planted with grass?

   **Figure 1. Question number 1**

In question number 1 students are expected to be able to understand problems in daily life related to mathematics, then students connect between mathematical topics related to the square area and circle area. In point b, students are expected to be able to represent approved results of mathematics to determine the remaining money they have. Based on the results of the analysis it is known that 1 student can answer correctly and give the right reasons for point a, 9 students can answer correctly and give wrong reasons, 6 students were able to answer correctly but did not write down the reasons, and 7 other students answered incorrectly. In general, students can model real-world problems into mathematical problems. However, there are still some student mistakes in answering question number 1 point a, among others students are not careful enough so that they only count square area and area of a circle, whereas to find out the land area, students should reduce the area of a square by the area of a circle. That is, students know the mathematical concepts, but cannot apply them to find solutions. The following is an example of student’s answers to questions number 1 points a.

![Figure 2: Example Incorrectly Calculation](image)

**Figure 2. Example Incorrectly Calculation**

Another mistake made by students is students miscalculating the multiplication operation as seen in the picture above. The results of the analysis on question number 1 point b are known as 13 students answered correctly and 10 students answered incorrectly. The following is one example of student answers.
Figure 3. Student can not represent the result of problem-solving

The mistake made by students are errors in the calculation process of multiplication operations. Besides, in the process of working students are not coherent and students have not been able to draw conclude so that they do not represent the results of problem-solving.

The Mistakes Made by Students on Question Number 2

Here is question number 2 which contains an indicator connecting mathematical material to other fields.

Problem number 2 shows the relation of mathematics with other fields that is physics and astronomy, more precisely the material around the circle with a matter of straight motion and the solar system. The relationship between mathematical topics is shown in question number 2 point b that is the relationship between the material around the circle as a distance (point a) and calculation of speed. Based on the results of the analysis there were 19 students answered correctly but could not write down the reasons for number 2 points a and 4 other students answered incorrectly. The following is an example of student’s answers to questions number 2 points a.
Figure 5. Students mistake to apply the formula
The mistake made by students based on the picture above is that students do not know the formula around the circle. Another error is that students are not able to distinguish the concept of the diameter and radius of the circle as shown in the following figure.

Figure 6. Wrong Concept
In question number 2 point b, none of the subjects answered the question correctly or it could be said that the related mathematical indicator linking mathematical topics was not fulfilled. This is seen from 23 students, none of them got a score on question number 2 points b. The following is one example of student answers.

Figure 7. The mistake in question understanding
The mistake made by students is that students do not understand the question and speed material, students do not pay attention to the unit intended by the question maker. In the results of this study, there was one student who considered the desired speed unit, which is km/hr, but due to miscalculations, this student failed to score. All students have tried to solve the problem even though it has not been maximal.
This is seen from no students who get the correct final answer. This fact shows that students have not been able to work on a circle problem that is associated with the concept of speed.

**The Mistakes Made by Students on Question Number 3**

As for question 3 which contains an indicator associating the concept of the Pythagorean Theorem, arc length and around flat shown in the following picture.

![Figure 8. Question Number 3](image)

In question number 3, none of the subjects answered the question correctly or the mathematical connection indicator was not fulfilled. This was seen from 23 students, only 1 student was able to apply the relationship between the Pythagorean theorem and the arc length. The following is the student’s answer.

![Figure 9. Students can connect concepts](image)

However, the student cannot get the right result. Meanwhile, 22 other students answered by writing a mathematical symbol but only showed students not understanding. This shows that the mathematical connection indicators related to connecting material between mathematical topics are still low. In addition to the results of the tests, researchers conducted interviews with several students who were the subjects of the study. Based on the results of the interview related to question number 3 where none of the students were able to answer the questions correctly, the subject had difficulty finding a concept that had to be associated with the concept of arc length and circumference to solve the problem. This is in
line with the results of the study of Lestari [15] and Pratini [16] each of which revealed that the lowest ability of students in the ability to connect between topics. This is in line with Kusmayadi [17] who argues that most students do not know and do not understand which material has to do with the material to be studied. The low level of connection ability between mathematical topics compared to real-world connections is partly due to a large number of mathematical topics that must be associated with problem-solving so that it requires broader thinking.

In question number 2 there were no students who were able to solve the problem correctly overall. Subjects have difficulty understanding questions because students are still confused and have not interpreted the sentence presented. This can be seen from the inability of students to write down the reasons why they should know the distance of the satellite from the center of the earth and the unit of velocity if it is known the time. This fact is in line with the results of Muncarno’s research [18] which states that students have difficulty understanding questions because students are not careful in reading and understanding sentences about things that are known, asked and how to solve the problem correctly. Research on analyzing student difficulties in mathematical connection skills in the material of the Pythagorean Theorem [16] shows that students cannot apply concepts that have been studied previously with the Pythagorean Theorem concept, so students have difficulty in solving problems. Students have difficulty understanding questions because students are still confused and have not been able to interpret the sentences presented. Besides, students forget the material of the Pythagorean Theorem. Students are also confused in choosing concepts that must be used in solving problems.

In general, the results of this study indicate that the mathematical connection ability of VIIIth grade junior high school students on the Circle material is low. However, students can be modeling real-world problems into mathematical problems. This shows mathematical connection ability on indicators applying mathematical concepts in solving real-world problems is better than connections between mathematical topics. However, the mistakes made by students in this research when solving mathematical problems were incorrect formula selection and incorrect calculation in number operations. This is in line with the statement of Budiyono [19] the types of mistakes students make in completing math problems are conceptual errors, including (1) error determining theorem or formula to answer the problem, (2) formula uses that are not applicable prerequisite conditions. The difficulty experienced by students in solving story problems is process skills. Difficulties in mathematical process skills in this study mostly occur when students carry out count operations. This shows the low mathematical connection ability.

4. Conclusion
Based on the results of this research, the mathematical connection ability is classified as low, this is indicated by the low percentage of students who give correct answers, the low percentage on each indicator of mathematical connections, and errors made by students. The most common mistake found in this research is a misunderstanding. The misunderstanding occurs when students fail to identify 'what is asked' and 'what is given' from the test problem. Students have difficulty understanding questions because they have not been able to interpret the sentences presented. Students difficulties in applying mathematical concepts in solving mathematical problems because students have not been able to determine precisely the use of formulas or theorems in solving mathematical problems. Besides, in the study [20] revealed that the most errors were misconceptions of concepts followed by miscalculations. In this study, students had difficulty solving mathematical problems because of calculation errors.

This research is limited to the categorization ability mathematical connection that has not gotten a proper solution to the above problems. Future research is expected to get a solution to overcome the low mathematical connection ability. Also, the data distribution in this study is still limited to one school only, so that it does not represent the overall data. Subsequent research can be developed in the wider domain for the same levels or different levels.
References
[1] Hanushek E A and Woessmann L 2012 J Econ Growth. 17 267
[2] Kruss G, Simon M, Petersen I and Gastrow M 2015 International Journal of Educational Development 43 22
[3] Papaioannou E and Ciccone A 2009 Review of Economics and Statistics. 91 66
[4] Hadi S, Retnawati H, Munadi S, Apino E and Wulandari N F 2018 Problems of Education in the 21st Century 76 520
[5] Shute V J and Becker B J 2010 Innovative Assessment for the 21 Century: Supporting Educational Needs (New York: Springer)
[6] Partnership for 21 Century Skills 2008 21 Century Skills, Education & Competitiveness: A Resource and Policy Guide (New York: ERIC Clearinghouse on Urban Education)
[7] NCTM. 2000. Principles and Standards for School Mathematics. United States of America : The National Council of Teachers of Mathematics, Inc.
[8] Linto, Rendya L, Elniati S and Rizal 2012 Jurnal Pendidikan Matematika 1 83
[9] Tipss S, Johnson A and Kennedy L M 2008 Guiding Children's Learning of Mathematics, 12th Edition (USA: Wadsworth)
[10] Sugiman 2008 Pythagoras 4 56.
[11] Bergeson, T 2000 Teaching and Learning Mathematics: Using Research to Shift From the “Yesterday” Mind to the “Tommorow” Mind [online www.k12.wa.us ]
[12] Kartikasari A and Widjajanti D B 2017 J. Phsy Conf Ser 812 012097
[13] Yin R K 2011 Qualitative Research from Start to Finish (New York: Guilford Publication Inc)
[14] Arikunto S 2012 Dasar-Dasar Evaluasi Pendidikan (Jakarta: Bumi Aksara)
[15] Lestari K E 2013 Implementasi Brain-Based Learning untuk Meningkatkan Kemampuan Koneksi dan Kemampuan Berpikir Kritis Matematis Siswa Sekolah Menengah Pertama (Tesis SPS UPI Bandung: tidak diterbitkan)
[16] Warih P D, Parta I N and Rahardjo S 2016 Proc. KNPM I Universitas Muhammadiyah Surakarta ISSN 2502-6526
[17] Kusmayadi 2011 Pembelajaran Matematika Realistik untuk Meningkatkan Kemampuan Komunikasi dan Pemecahan Masalah Matematis Siswa SMP (Tesis SPS UPI Bandung: tidak diterbitkan)
[18] Muncarno 2008 Penerapan Model Penyelesaian Soal Cerita Dengan Langkah-Langkah Pemecahan Masalah Untuk Meningkatkan Prestasi Belajar Matematika Siswa Kelas I SMP (Lampung: LPMP Universitas Lampung)
[19] Budiyono 2008 Jurnal Penelitian Pendidikan. 11
[20] Agustyaningrum N, Abadi A M, Sari R N and Mahmudi A 2018 J. Phys.: Conf. Ser. 1097 012118