Junior high school students' mathematical connection: a comparative study of children who have reflective and impulsive cognitive styles

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Abstract. Mathematical connections are the link between mathematical topics and mathematics, with other disciplines and to the real world or in daily life. The purpose of this study was to describe the mathematical connection ability of junior high school children who have impulsive and reflective cognitive styles. To achieve that objective, comparative research is done both qualitatively and quantitatively between reflective and impulsive students. The research subjects were students of SMP Negeri 1 Palang who had impulsive and reflective cognitive styles. To measure impulsive and reflective cognitive styles the MFFT (Matching Familiar Figures Test) instrument is used. The mathematical connection instrument is a mathematical connection test while exploring the mathematical connection skills used by task-based interviews. Based on the results of the qualitative analysis, it was concluded that reflective students can recognize and use the relationship between ideas in mathematics better than impulsive students. Reflective students are also able to show quite well how mathematical ideas are interconnected and build on each other to produce a coherent whole, but impulsive students are less able. On indicators of recognizing and applying mathematics in contexts outside mathematics, both reflective and impulsive children have the same difficulty. The results of the statistical analysis of the mathematical connection score, there were no significant differences between reflective and impulsive students.

1. Introduction

According to [1] mathematical connection as a skill is not merely the ability to calculate and manipulate symbols, but mathematical abilities are used as tools, resources, procedures, knowledge, and way of thinking developed over time to understand new situations. The mathematical connection is the link between mathematics topics with mathematics, with other disciplines and with the real world or in everyday life. Mathematical connections are inspired that mathematics is not partitioned on a variety of separate topics, but mathematics is a unity. Besides, mathematics also cannot be separated from science other than mathematics and the problems that occur in life. Without a mathematical connection, students must learn and remember too many separate mathematical concepts and procedures [2]. Students of all school ages need to see the relationships and connections between mathematical ideas and their representations [3,4]. [5] says that interconnection in mathematics refers not only to mathematical objects and scientific topics but also to the relationship between mathematics.
According to [6] mathematical connections are designed to provide students with experiences that excite their curiosity, stimulate their imagination, and challenge their skills. In classroom learning, mathematical connections between concepts in mathematics should be discussed by students, the connection between mathematical ideas explicitly taught by the teacher does not make students understand them meaningfully (Hiebert and Carpenter, in [7]). If students can link mathematical ideas, their mathematical understanding will be deeper and last longer because they can see the interrelationships between topics in mathematics, with contexts other than mathematics, and with experiences of daily life [2]. According to [8] the ability of students to build different connections and to reduce the gap between school mathematics and real-life depends on how much they can use mathematics in the classroom to real life.

The most fundamental aspect of RME (Realistic Mathematics Education) is a mathematical concept developed based on problems in a real-life context. In other words, the RME theory is a mathematical concept introduced to students in certain situations [9,10]. In RME theory, mathematical concepts are taught to students by providing examples of real-life situations that are meaningful to them [9]. According to [11] the ability of mathematics teachers to connect mathematics with real life and the surrounding environment has been shown to have a positive and significant impact on student achievement. The link between mathematics and real-world problems is important to discuss because the relationship between the two can increase interest and motivation in mathematics, contribute to students' preparation for facing the real world, develop positive attitudes towards mathematics, and develop an understanding of concepts [12–15]. However, what affects the ability of teachers to make connections, according to [16] the ability of teachers to connect mathematics with real-life problems is significantly influenced by the quality, connection learning, and teacher motivation.

Using real-world connections in mathematics is one way to overcome abstract mathematical problems [17]. Mathematics is connected with the real world as a way to increase student motivation. Besides, it can provide benefits such as facilitating understanding of mathematical concepts, motivating and improving students' attitudes towards mathematics [12,18]. According to [13] the advantage of using mathematics connected to the real-world is to help develop or improve: a) Interest and motivation in mathematics (96%); b) Students' attitudes towards mathematics become positive (92%); c) Reasoning and problem-solving as process skills in mathematics (96%); d) Permanent and conceptual learning (100%); e) Awareness of future career choices (88%); f) The ability to generalize mathematical ideas (75%).

Referring to the description above, mathematical connections are made through reasoning and generalizing mathematical ideas, on the other hand, the characteristics of each student in thinking have a different way or process. Will the difference in students' thinking styles (cognitive styles) result in different mathematical connection abilities? Cognitive style is an individual characteristic in remembering, organizing, processing, and solving problems, to distinguish, understand, store, manifest, and utilize information [19–21]. One's learning style is influenced by cognitive style factors. Cognitive style is a psychological construction related to how information is processed by individuals [22], has many kinds of cognitive styles that have been introduced by experts. It was once classified into field-dependent and field-independent styles, global and analytic styles, impulsive and reflective styles, and intolerance and tolerance of ambiguity. Many researchers assume the same between learning styles and cognitive styles, while others have different opinions. Cognitive style and learning styles are different. Cognitive style is "the way of individual habits in organizing and processing information" [23], while learning style is a broader concept. In addition to information processing, "learning styles also contain feelings and psychological behavior of individuals" [24].

Research results [25] show that cognitive style has a significant influence on the choice of students' learning strategies. In terms of critical thinking, [26] findings show that there is a strong positive relationship between critical thinking and reflectivity, however, and there is a weak negative relationship between critical and impulsive thinking. Correspondingly, [27] explains that learning styles that refer to the cognitive style that an individual has (ie the relationship between cognition and
individual personality) in the context of the educational process, show the preferred way for someone to approach new information.

This study focuses on the cognitive style proposed by Jerome Kagan in 1965, namely the reflective and impulsive cognitive style. Impulsive children are children who have the characteristics of quickly answering problems, but are not / less accurate, so answers tend to be wrong. And reflective children are children who have the characteristics of being slow in answering problems but are accurate, so answers tend to be correct [20,21]. Are students who have the characteristics of being quick in answering, but not / less accurate, mathematical connection skills will be better or vice versa? Likewise, do students who have the characteristics of being slow in answering but be accurate, the ability of mathematical connections will be better or vice versa? For this reason, it is necessary to research with reflective or impulsive student subjects. According to [28] reflective systems produce behavioral decisions based on knowledge of facts and values, whereas impulsive systems bring up behavior through associative links and motivational orientation. While according to [29] the characteristics of reflective individuals apply analytic and adult processes cognitively, while impulsive individuals use holistic processes and are cognitively immature. In terms of problem-solving creativity, [21] research results show that students who have a reflective cognitive style have the ability to creativity (fluency, flexibility, and novelty) in solving geometry better than students who have impulsive cognitive styles. Students who have impulsive cognitive styles make a lot of mistakes and are less systematic in solving problems, so it is less effective resulting in answers that tend to be wrong. [30] research findings show that reflective students achieved significantly higher than their impulsive counterparts in mathematics achievement.

Referring to the description above, the main problem is how is the mathematical connection of children who have impulsive and reflective cognitive styles? Are there differences in mathematical connection abilities between children who have impulsive and reflective cognitive styles? The purpose of this study in detail is a) describe the ability of children's mathematical connections that have reflective and impulsive cognitive styles; b) Knowing the presence/absence of differences in the ability of mathematical connections between children who have impulsive and reflective cognitive styles.

2. Research Method

This study intends to: a) describe the ability of children's mathematical connections that have reflective and impulsive cognitive styles; b) examine the presence/absence of differences in the ability of mathematical connections between children who have impulsive and reflective cognitive styles. To obtain a description of mathematical connections, the first step of the subject was given a mathematical connection test, then to explore the ability of mathematical connections explored with task-based interviews with the research subjects. Meanwhile, to find out the differences in mathematical connection ability, a comparative study was carried out between the test scores of impulsive and reflective children's mathematical connection abilities. For this reason, this type of research is an explorative comparative study. The research subjects were students of SMP N Palang, Tuban who had reflective and impulsive cognitive styles. The instrument to determine the reflective-impulsive cognitive style was developed by [20] from a test made by Jerome Kagan, the MFFT (Matching Familiar Figure Test). Based on the measurement of cognitive style, there are 14 impulsive students (32.56%) while reflective students have 17 students (39.53%). This shows that the proportion of students who have reflective or impulsive characteristics is greater at 72.09%. The remaining 27.91% are students who have the characteristics of fast and accurate/accurate in answering or are slow and less precise / less accurate in answering.

The selection criteria for the subjects interviewed included: 1) The reflective group was taken from students who had the longest time record and were careful/accurate in answering (the wrong frequency was a little). Then, the impulsive group is taken from students who have the fastest and most inaccurate/incorrect time records (many wrong frequencies) in answering. It is intended that the selected students are truly reflective or impulsive. 2) Being able to communicate opinions/ways of
thinking verbally and in writing. Based on these considerations, initial reflective subjects were obtained: UA, NI, and impulsive subjects: UN, and MRI.

The main instrument is the researcher himself, and the supporting instrument is a mathematical connection test in the form of problem-solving refers to mathematical connection indicators and interview guidelines. Interview guidelines refer to mathematical connection indicators. Indicators to measure the ability of mathematical connections, namely: a) recognize and use connections among mathematical ideas; b) understand how mathematical ideas are interconnected and build on one another to produce a coherent whole; c) recognize and apply mathematics in contexts outside of mathematics” [2]. The interview guide serves to explore/explore students' mathematical connections in solving problems. The core questions that are used refer to indicators of mathematical connections but emphasize how students in oxidizing the problem.

To establish the validity of the data required examination techniques, through verification with task-based interviews. Furthermore, the data were analyzed qualitatively. Qualitative data analysis refers to [31] including data reduction, data presentation, and concluding. This statistical data analysis is used to analyze quantitative data in the form of mathematics connection test scores to determine differences in the mathematical connection abilities of students who have reflective and impulsive cognitive styles. To test the differences in the ability of children's reflective and impulsive mathematical connections, a nonparametric test is used, namely the Mann-Whitney test.

3. Results and Discussion
Next, the reflective and impulsive students' mathematical connection profiles will be discussed in a row. To answer the problem in this study, researchers have conducted a mathematical connection test on the topic of geometry with the sub-topic beam and cube, for class VII SMP N Palang. In describing the ability of mathematical connections the writer only pours the subject being interviewed. To test the difference in connection capabilities based on the results of the mathematics connection test scores.

3.1 Recognize and use connections among mathematical ideas
As an illustration, here is one of the reflective and impulsive student answers to the problem: “The ratio of the length, width, and height of a beam is known = 6: 5: 4. If the base of the block is 480 cm², then calculate the surface area of the beam!”

![Figure 1](image)

**Figure 1.** Pieces of answers: (a) UA reflective students, (b) UN impulsive students

Note the answers to Figure 1. (a) Reflective students show that UA can recognize ideas by writing down what is known and what is asked in solving problems. UA subjects are also able to use ideas to make mathematical models in solving problems properly. However, when asked about the relationship between the comparison of the ribs with the ratio of the surface area, UA could not explain. A similar case occurred in NI reflective students, also unable to illustrate when comparing beam ribs with the surface area. Students who have a reflective cognitive style according to [32] read more than once to
identify what is asked and write what is known, build relationships in each element and connect information with arithmetic operations, connecting between what is asked with known information. For the students’ impulsive UN answers (Figure 1. (b)) shows that the UN can recognize ideas by writing down what is known and what is asked in solving problems. But the UN is less able to use ideas to make mathematical models in solving problems (not careful enough). Similar cases occur in impulsive MRI students who are not able to make mathematical models, so the answers are wrong. Students who have impulsive cognitive styles according to [32] attention to important elements in understanding problems, build connections in each element, connect information with arithmetic operations, build relationships about problems comprehensively by connecting between what is asked with known information.

3.2 Understanding how mathematical ideas are interconnected and building on one another to produce a coherent whole.

As an illustration, here is one of the reflective and impulsive student answers to the problem:

Consider the following cube nets!

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5
1 2 3 4
6
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(a) If the image above is number 3 as the base, then the cap is number ...

(b) If the cube above has a surface area of 1,014 cm$^2$, then determine the length of the side of the cube

Looking at the answer UA in Figure 2. (a), especially part b) looks less accurate, so the answer finally becomes wrong. This incident could be inaccurate (careless) or indeed UA is not a good form of root retention. Then an analysis of the results of the verification through an interview with the UA, obtained a dubious answer when asked about the writing of the root form, although clearly, it is two different things. But for NI reflective students the writing done especially part b) is correct, so the result is also correct, which is 13 cm. Referring to this fact, it can be said that reflective students tend to be able to make connections between one concept and another in solving a problem. The term is in line with [32] that students who have a reflective cognitive style build relationships in each element and connect information with arithmetic operations, connecting between what is asked with known information.

For impulsive students, it is seen in the answer sheet (Figure 2 (b)), the UN has not yet completely solved this problem. As for the MRI subject, there are answers, but they are not accurate, especially the answer in part b) is wrong. So impulsive students are less able to make connections between one
concept with another concept in solving problems. This contradicts the finding [32] that students who have impulsive cognitive style build relationships about problems comprehensively by connecting what is asked with known information.

3.3 Recognize and apply mathematics in contexts outside mathematics
As an illustration, here is one of the reflective and impulsive student answers to the problem: “Nadira begged her brother to decorate all the corners of the trophy which is placed in a block-shaped box with a ribbon. The size of the Nadira trophy is 10 cm x 10 cm x 30 cm. What is the minimum length of ribbon that is needed by you to decorate the trophy place?”

![Figure 3. Pieces of answers: (a) UA reflective students; (b) UN impulsive students](image)

Consider the answer UA in Figure 3. (a) students are asked to use mathematics to solve everyday problems. UA understands the problem, and can use mathematical models, especially blocks to solve problems, even though the unit has written incorrectly, "cm³" should be "cm". The author tries to clarify, UA realizes that it is a unit of length, but remembers the symbols 'p', 'l', and 't' in the volume formula, so the unit is written "cm³". However, UA is less able to apply concepts in solving problems. The same case happened to NI reflective students. Referring to these facts, it can be said: reflective students can interpret real-life problems into mathematical models but have difficulty in applying concepts to solve real-life problems. This finding is in line with the results of the study [32] that students who have a reflective cognitive style can create an equation model to find out values using substitutions, and establish connections to re-examine, re-read, and re-calculate.

Looking at the answer sheet (Figure 3. (b)) above, the UN is less accurate in writing mathematical formulas/models, it should be 4 x (p + l + t), so the UN answer is wrong. However, whether the UN is careless or does not know that it is wrong. The results of clarification to the UN obtained the same results. According to [33] impulsive individuals are usually faster readers, and eventually master the game of psycholinguistic guessing, so their impulsive reading style might result in incompatible understanding. The results of the study [34] showed that although there was no significant relationship between the dimensions of reflectivity and language skills, a slight negative correlation was found between the dimensions of impulsivity and language skills but was not significant. But for impulsive students, MRI is quite capable of interpreting real-life problems into mathematical models. Analysis of the second problem, the UN found difficulty in applying concepts to solve real-life problems. The same case occurs in the impulsive subject of MRI. Referring to this fact, it can be said: impulsive students are less able to interpret real-life problems into mathematical models and have difficulty in applying concepts to solve real-life problems. This finding is in line with [32] students who have impulsive cognitive styles look for unknown values using arithmetic operations without making any equation model. The results of double-checking problem solving, impulsive students only skim over without recalculating the results of problem-solving. This is also in line with studies [8] which show that the skills of grade 8 students connecting mathematics with real-life are not at an adequate level. Most students can only connect mathematics in real life with numbers and shapes.
3.4 Mann Whitney Test Results
Furthermore, to answer differences in mathematical connection abilities between students who have reflective and impulsive cognitive styles, a difference test will be conducted. Given the very few research subjects, the normality of the data is ignored, so it uses the non-parametric test, the Mann Whitney test.

Table 1. Mann Whitney test results

| Test Statistics         | Nilai |
|-------------------------|-------|
| Mann-Whitney U          | 45.500|
| Wilcoxon W              | 81.500|
| Z                       | -.717 |
| Asymp. Sig. (2-tailed)  | .473  |
| Exact Sig. [2*(1-tailed Sig.)] | .482 |

Based on Table 1. Sig. (2-tailed) is 0.473 which is greater than 0.05, so Ho's decision is accepted, so the conclusion is that there is no significant difference in the value of the average connection ability between students in a cognitive reflective and impulsive style.

4. Conclusion
Based on the results of the analysis both qualitatively and quantitatively it can be concluded as follows.

a. Students' mathematical connection skills that have a reflective cognitive style can recognize ideas by writing down what is known and what is asked in solving problems. Able to use ideas to make mathematical models in solving problems well. Reflective students tend to be able to make connections between one concept with another concept in solving problems. It was also found that reflective students were able to interpret real-life problems into mathematical models, but had difficulty in applying concepts to solve real-life problems.

b. Mathematical connection skills of students who have impulsive cognitive styles can recognize ideas by writing down what is known and what is asked in solving problems but are less able to use ideas to make mathematical models in solving problems (inaccurate). Impulsive students are less able to make connections between one concept and another concept in solving problems. It was also found that impulsive students were less able to interpret real-life problems into mathematical models, and had difficulty in applying concepts to solve real-life problems.

c. The results of the analysis of the different tests obtained no significant difference in the ability of mathematical connections between students who have both reflective and impulsive cognitive styles.

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