Adaptive Reasoning, Mathematical Problem Solving and Cognitive Styles

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*Abstract*—This paper examines the relationship between adaptive reasoning, problem solving and cognitive styles. In particular, field independent (FI) and field dependent (FD) cognitive styles. Adaptive reasoning in mathematical problems to legitimacy of problem strategies. Whereas in the cognitive style, it provides opportunities for students to give reasonable arguments according to the tendency of the cognitive style. Mathematical problem solving in the FI and the FD can vary according to students' cognitive styles. Adaptive reasoning, mathematical problems, as well as the cognitive styles of FI and FD all have a strong stylistic relationship where adaptive reasoning will be able to give direction to students in solving math problems and students' problem abilities depend FI, and FD.

Keywords—relationship; adaptive reasoning; problem solving; cognitive styles

# Introduction

There are several competencies that students must have, one of the skills of reasoning, processing, and presenting creatively, productively, critically, independently, collaboratively, and communicatively, in the realm of the concrete and the abstract realm according to what is learned in schools and other sources. From a theoretical point of view [1]. The importance of reasoning in learning can be shown that this competency is one of the goals of mathematics education in primary and secondary education, namely students are able to use reasoning on patterns and traits, carry out mathematical manipulation in generalizations, compiling evidence, explaining mathematical ideas and statements. Reference [2,3] which states that mathematical reasoning is the basis for obtaining or constructing mathematical knowledge. Thus, mathematics teachers should develop students' reasoning abilities in the mathematics learning process.

Reasoning ability is one of the mathematical powers of concern in learning mathematics as stated in the general aims of learning mathematics which are formulated in the standard process proclaimed by the National Council of Teachers of Mathematics (NCTM), namely the achievement of the process standard consists of: (1) mathematical problems solving, (2) reasoning and proof, (3) mathematical communication, (4) mathematical connection, and (5) mathematical representation [4]. It appears that in these five standard processes, reasoning becomes one of them, so that reasoning becomes important in mathematics learning.

According to [5] there are two important factors that play a big role in students' success in learning mathematics. The first reason is from outside the students such as teachers, curriculum, and environment/ class, while the second reason is from the students themselves, namely mathematical skill.  There are two parts to reasoning in mathematics, namely inductive reasoning and deductive reasoning [6]. Meanwhile, reasoning that includes both reasoning by NRC (National Research Council) is called adaptive reasoning [7]. According to [8] many concepts in mathematical reasoning are limited to formal proof and other forms of deductive reasoning. The notion of adaptive reasoning is much broader, encompassing not only informal explanations and justifications but also intuitive and inductive reasoning based on patterns, analogies, and metaphors. Adaptive reasoning is the capacity to think logically about the relationship between concepts and situations, so that reasoning will be valid correctly based on the alternative arguments given, and the ability to give conclusions [8,9,10]. If adaptive reasoning is not developed for students, students only consider mathematics to be a lesson by applying formulas and a series of ways in solving problems given by the teacher through examples without knowing their meaning and application.

The process of thinking in problem solving should get the attention of teachers, especially to develop students to become accustomed to thinking logically. Teaching students to solve problems allows students to be more analytic in making decisions in their lives because students will get used to collecting relevant information, analyzed information, and re-examining the results they get [11]. Problem solving refers to active efforts to find what must be done to make goals that are not easily achieved [12]. Furthermore, in solving a problem, you can use the following steps: (1) understanding the problem, (2) devising a plan, (3) carrying out the plan, and (4) looking back [13].

Each person has a different way of knowing, seeing, and organizing information and choosing their preferred way of organizing and processing information in response to environmental stimuli. Whereas in [14], the cognitive style is a personal character and a consistent approach to organizing and processing information. Based on the psychological differences the cognitive style consists of field independent (FI) and field dependent (FD) cognitive styles, where students who have the FI cognitive style tend to perceive separate parts of a pattern according to its components, while students who have the FD cognitive style tend to perceive a pattern and it is difficult to focus attention on one aspect of a situation or a pattern into various kinds [15].

It is necessary for a teacher to know the potential of students' reasoning before developing and improving it because by knowing the student's reasoning, the teacher is expected to be able to plan and make optimal learning. Given the importance of adaptive reasoning, problem solving and cognitive styles, this article examines (1) the relationship of adaptive reasoning to mathematical problem solving, (2) the relationship of adaptive reasoning to FI and FD cognitive styles, (3) the relationship of mathematical problem solving to FI and FD cognitive styles, (4) the relationship between adaptive reasoning, mathematical problem solving, and FI and FD cognitive styles.

# THEORITICAL REVIEV

## Adaptive Reasoning

Adaptive reasoning is the capacity to think logically about the relationships between concepts and situations. Adaptive reasoning is one of the skills that students must have to support their learning abilities. In general, reasoning is divided into two categories, namely deductive reasoning and inductive reasoning. Reasoning that includes deductive reasoning and inductive reasoning by NRC is called adaptive reasoning. Adaptive reasoning can be defined as the ability to think logically in explaining, providing solutions and providing conclusions from a given mathematical problem [8,16,17]. Adaptive reasoning is the ability to think logically, say, explore and prove a given problem. Adaptive reasoning abilities appear in students when they are able to prove their work, namely when they check their work, both their own work and the work of others and are able to explain ideas to make reasoning clear so that it can lead to their reasoning abilities and be able to build understanding of concepts.

Reference [8,18] says that students can show their adaptive reasoning skills when they meet three conditions, namely: (1) they have a sufficient knowledge base, (2) the task is understandable and motivating, (3) the context is familiar and comfortable. Based on several explanations about the notion of adaptive reasoning, according to the opinions, adaptive reasoning is a process of thinking logically about the relationship between concepts and situations to find solutions to a given mathematical problem. Meanwhile, indicators of adaptive reasoning are (1) logical thinking, (2) the relationship between concepts and situations.

## Problem solving

Problem solving is the process of applying someone's knowledge to solve problems in new or specific situations [4,19,20,21,22]. The ability to solve problems as an individual means to use the knowledge and abilities that have been previously owned to be synthesized and applied to new and different situations [23]. The problem-solving indicators are (1) building new mathematical knowledge through problem solving, (2) implementing and adjusting various right strategies for solving problems, (3) solving problems that arise in mathematics and in other contexts, and (4) monitoring and show on the process of solving mathematical problems [4].

 According to [28], the Polya model has been implemented to solve mathematical problems both in mathematics learning in primary, secondary and higher education, even in tertiary institutions as a basis for solving math problems. Solving problems in accordance with the desired objectives cannot be achieved easily and requires a relatively long time [13]. This means that a solution to the problem cannot be found immediately.

From the opinions of some of the above opinions, according to the authors, solving mathematical problems is an effort to get problem solutions that involve thinking skills, reasoning, knowledge by using problem solving steps according to Polya, namely: (1) understanding the problem, (2) planning solutions, (3) doing plan, and (4) re-examine the settlement.

## Cognitive Style

From the personal aspects of students, which is closely related to the success of student learning, the cognitive aspect, the function of cognition includes: intelligence level, creativity power, special talents, cognitive organization, language ability level, fantasy power, cognitive style, learning type, thinking styles, and study techniques. Learning styles include several components, including: learning types and cognitive styles. Cognitive style is a characteristic of a person in accepting, analyzing and responding to a given cognitive action [25].

The development potential of students really needs to be understood by a teacher and parents to be able to properly select teaching materials and other knowledge deemed necessary [26]. Teachers and students have their own preferred ways of structuring what they see, remember, and think. Persistent each difference in how to organize and process information and experiences are known as cognitive styles. Cognitive style reflects stable and consistent attitude in people in remembering information, receiving, thinking about and solving a problem. This shows that the cognitive style describes the attitude habits of an individual in processing information [27,28]. Cognitive style is an individual characteristic that is consistent in obtaining, organizing and processing information. Based on the above opinion, the cognitive style according to the author is how a person thinks, remembers, processes and solves problems and makes decisions.

There are many variations of cognitive styles that are of interest to educators, and they differentiate cognitive styles based on dimensions, namely: (1) differences in psychological aspects, consisting of FD and FI, (2) differences in conceptual tempo, consisting of impulsive and reflective styles [29]. Furthermore, he differentiates cognitive styles into 3, namely: (1) impulsive-reflective, (2) FD)-FI and (3) verbal imagery-nonverbal imagery. Meanwhile, as in [30], classifies cognitive styles into 3 types, namely: (1) FD, (2) FI, (3) intermediate field (FDI), tend to have abilities like FD or FI students because FDI lies between the two. In its implementation in education, the most considered cognitive styles are (1) FD and (2) FI [31].

# DISCUSSION

## The Link Between Adaptive Reasoning and Problem Solving

Adaptive reasoning is closely related to problem solving because it acts as a determinant of the legitimacy of problem-solving strategies [8], adaptive reasoning interacts with several other mathematical skills, especially problem solving. Students demonstrate strategic competence to formulate and present a problem, using their heuristic approaches that give a resolution strategy, but adaptive reasoning plays a role when determining the legitimacy of the proposed strategy. Someone who has adaptive reasoning knows that the solution or answer they get is correct not because they use certain ways but because they solve problems in a logical way and are able to prove their solution [32]. Thus, students who have adaptive reasoning skills easily know the solution they get is correct by justifying the steps they use to get the solution.

Adaptive reasoning is closely related to problem solving because in problem solving strategies, adaptive reasoning acts as a determinant of legitimacy [33,34]. This means that solving problems are an effort that involves thinking and reasoning skills to get a solution to a problem using mathematical knowledge.

Adaptive reasoning is the capacity to think logically, think reflectively, give explanations, and provide justification [8]. Adaptive reasoning acts as the glue that holds these components together. This shows that adaptive reasoning is the ability to think logically, say, explore and prove a given problem. This means that adaptive reasoning is related to the ability of students to solve problems where when students find a problem-solving strategy, the students will decide the legitimacy of the proposed strategy, so that adaptive reasoning plays a role in the process.

Adaptive reasoning is a critical thinking skill where critical thinking is needed in finding a solution to a problem. So that adaptive reasoning can solve problems easily. Adaptive reasoning is closely related to problem solving because it plays a role when determining the legitimacy of the problem-solving strategy used [8]. Someone who has adaptive reasoning knows that the solution (answer) they get is correct not because they use a certain procedure but because they solve the problem in a logical way and are able to prove their solution [32]. Based on the expert's opinion, it can be seen that students who have adaptive reasoning abilities easily find out the correct solution they get by justifying the steps they use to get the solution.

Based on [35], through adaptive reasoning students will be able to solve problems quickly, accurately and students will build their minds to master mathematical concepts for now, later and become the basis for students to act logically in mathematical activities or in their daily activities. By getting children to reason and intuition properly from now on, we can hope that children can be responsible for their thinking and be able to solve new problems using guesswork or analytically. Through adaptive reasoning, it keeps students from just memorizing concepts, but it is further from that.

Adaptive reasoning that is closely related to problems, this is because this ability is mainly used by children when faced with math problems that must be the meaning [36]. In mathematics learning, good mathematical reasoning skills in understanding concepts and problem. Reasoning is involved in the problem process because, indeed, some forms of reasoning are usually part of the problem itself.

The relationship between adaptive reasoning and problems in mathematics is presented in Table 1 below:

1. Linkage of Adaptive Reasoning and Mathematical Problem Solving

|  |  |  |  |
| --- | --- | --- | --- |
| **Stages Polya** | **Adaptive Reasoning** | **Adaptive Reasoning Problems in Mathematics** | **Code** |
| Understanding the problem | Think logically about the relationships between concepts and situations | 1. Students mention things they know and why. 2. Students find the relationship between concepts and things that are known. 3. Students mention something asked along with the reasons. 4. Students find the relationship between the concepts and the things being asked. 5. Students find the relationship between things that are known and things that are asked. | UA1  UA2  UA3  UA4  UA5 |
| Devising a plan |  | Students formulate plans to complete plans   1. Making models 2. Plans in relating situations to concepts 3. Plans to relate the situation to the situation 4. Plans in linking concepts to concepts 5. Plans in completing the model: 6. Plans in linking concepts to concepts | PA1  PA1.1  PA1.2  PA1.3  IA2  IA2.1 |
| Carrrying out the plan |  | Students apply the plans that have been made:   * 1. Carry out the plan in making the model:  1. Using the link between situations and concepts 2. Using the relationship of situation to situation 3. Using concept-concept linkages    1. Carry out the plan for completing the model: 4. Using concept-concept linkages    1. Computing | IA1  IA1.1  IA1.2  IA1.3  IA2  IA2.1  IA3 |
| Looking back |  | Checking the validity of the relationships made in making conclusions. | L |

Based on the description above, adaptive reasoning in solving mathematical problems is the ability to think logically about the relationship between concepts and situations to find a problem solution by using problem-solving steps according [13], namely: (1) understanding the problem, (2) planning completion, (3) implementing the completion plan, and (4) re-checking the settlement.

## The Relationship Between Adaptive Reasoning and Cognitive Style

Mathematical abilities are related to a person's potential which includes knowledge and skills in carrying out various activities such as thinking, reasoning, solving problems, and so on, so that FI and FD cognitive styles have a relationship or influence with reasoning, namely adaptive reasoning [37]. Each person will choose the preferred way of processing and organizing information in response to environmental stimuli.

Psychological differences between FI and FD cognitive styles, where students who have a FI cognitive style tend to perceive separate parts of a pattern according to its components, while students who have a FD cognitive style tend to perceive a pattern and find it difficult to focus their attention on one aspect of the situation or analyzation a pattern into various kinds [15]. In solving problems, students who have a FI cognitive style use their own perceptions and analytics, systematically using various processes and strategies. Meanwhile, students who have FD cognitive style are intuitive in problem-solving steps, not systematic and find it difficult to develop processes and strategies. When people think logically in looking for linkages between concepts and situations or do adaptive reasoning in finding solutions or solving mathematical problems, the characteristics inherent in people in thinking, remembering, processing and solving problems and making decisions in response to environmental stimuli shows a different way when viewed from the cognitive style of FI and FD where adaptive reasoning in solving problems of students with the FI cognitive style tends to be better than students with the cognitive style of FD. This is in [38], arguing that FI people are superior to FD people. This is certainly interesting to study more deeply how the differences occur. Based on the tendency of students with FI and FD cognitive styles, they are closely related to students' adaptive reasoning in solving problems because adaptive reasoning is reasoning that provides opportunities for students to give reasonable arguments based on mathematical properties when looking for relationships between concepts and situations. Have different strategic characteristics in understanding, choosing strategies, making conclusions and providing arguments.

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## The Link Between Adaptive Reasoning, Problem Solving and Cognitive Style

There is an effect of students' adaptive reasoning ability on the ability to solve mathematical problems where adaptive reasoning abilities will be able to give direction to students in solving math problems because by reasoning a problem it can help students to solve problems [39]. Thus, adaptive reasoning is part of problem solving.

Meanwhile, students' problem-solving abilities in mathematics can be influenced by several factors where these factors arise because everyone has differences. This is consistent with [32] which states that the dimensions of differences include intelligence, logical thinking skills, creativity, cognitive style, personality, values, attitudes, and interests. This shows that problem solving is related to the cognitive style.

Problem-solving also involves mental activity which is reflected in the cognitive style to receive and process information requiring knowledge and experience to have a habitual impact on students' propensity to process information. Students' cognitive style has a strong relationship with students' mathematics performance (refers to the individual's capacity to deal with changing job needs and new or unusual situations) of students' mathematics [32].

Students' mathematical problem-solving abilities, this is in accordance with the opinion [40]. It is not surprising that researchers around the world are very interested in examining the relationship between cognitive style dimensions and mathematical problem-solving abilities [41]. One of the results of research related to cognitive style with mathematical problem-solving abilities is that the research results show that students' problem-solving abilities are influenced by cognitive styles where the higher level of students' cognitive styles, the higher students' mathematical problem-solving abilities [42].

Different cognitive styles of students can affect students' ability to think, reason, and use information in solving problems [43,44,45]. As in [46] it said that cognitive style is one of the learning conditions which one of the considerations in designing learning. This is because this cognitive style is seen as a determining variable on students' ability to solve story problems. This means that people who have the same cognitive style may not necessarily have the same abilities. Moreover, if the person's cognitive style is different, the tendency for differences in their abilities is greater. This is because the cognitive style shows variations between one person and another in terms of carrying out a task, but that variation does not show a certain level of intelligence or ability of an individual.

Furthermore, the role of cognitive style in the learning process refers to the views of experts on the dimensions of cognitive style. Implementation in learning greatly determines the success of learning [30]. A student who has a cognitive style FD, global perceptual feels a heavy burden, has difficulty processing, and is easy to perceive when information is manipulated according to the context. Someone who has a cognitive style FI psychological differentiation, articulation will perceive it analytically. He will be able to separate the stimuli in the context, but his perception is weak when the context changes. However, psychological differences can improve through a variety of situations. Individuals in the FI group usually use internal factors as directions in processing information. People with FI work out of order and feel efficient working alone. FI students are generally not easily distracted and are not easily confused, so they have good problem-solving skills. FI students in identifying problems tended to make fewer mistakes than FD students. It can be said that FI students have the ability to read or find problems better than FD students. The ability to find this problem is in accordance with one indicator of adaptive reasoning, namely students are able to understand information immediately. So that FI students tend to have good adaptive reasoning. The result in [47], FI students showed better problem-solving abilities compared to FD students because they had good reasoning. Furthermore, FI students showed higher results compared to FD students in solving complex word problems. This is because FI students are more analytical in connecting concepts to problem situations, are easy to focus on key features in problem situations and are not affected by the distracting components in problem situations [31]. This illustrates that FI students have better adaptive reasoning. Meanwhile, FD students tend to deal with problems globally and passively, and are influenced by external factors. Furthermore, to find the relationship between situations, concepts, representations, formulation, and very limited in choosing the right strategy. This suggests that adaptive reasoning is related to the cognitive styles of FI and FD.

# CONCLUSION

The linkage of adaptive reasoning, problem solving and cognitive style field independent (FI) and field dependent (FD) is as follows:

1. The relationship between adaptive reasoning and mathematical problem solving, namely, adaptive reasoning, acts as a determinant of the legitimacy of problem-solving strategies.

2. The linkage of adaptive reasoning with FI and FD cognitive styles, namely adaptive reasoning, provides opportunities for students to give reasonable arguments based on mathematical properties when looking for linkages between students' concepts and situations based on student tendencies with FI and FD cognitive styles.

3. The relationship between solving mathematical problems and the cognitive styles of FI and FD is similar, that is, everyone has a different way of dealing with problems according to different characteristics based on FI and FD cognitive styles.

4. The linkage of adaptive reasoning, mathematical problem solving, and FI and FD cognitive styles, namely adaptive reasoning, will be able to give direction to students in solving mathematical problems and students' problem-solving abilities are influenced by FI and FD cognitive styles.

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