Jurnal Kependidikan:
Jurnal Hasil Penelitian dan Kajian Kepustakaan di Bidang Pendidikan, Pengajaran dan Pembelajaran
https://e-journal.undikma.ac.id/index.php/jurnalkependidikan/index
Vol. 9, No. 3 : September 2023
E-ISSN: 2442-7667
pp. 1050-1059
Email: jklppm@undikma.ac.id

Causes of Student Errors in Solving Numeration Problems : A Case Study on Students with a Strongly Field Independent Cognitive Style

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Abstract: This research aims to uncover the causes of errors in solving numeracy problems related to trigonometry among students with a strongly field-independent cognitive style. The research method employs a case study with a qualitative approach. The subjects of this study are students of class XI MA Ibadurrochman Malang. The instrument in this study consists of the main instrument, namely the researcher himself and supporting instruments consisting of GEFT (Group Embedded Figure Test) sheets and Numeration Problem Solving Test Sheets (TPMN) and interview guidelines. This data analysis technique used interactive model analysis. The research findings indicate that the causes of student errors in solving numeracy problems are primarily rooted in their previous knowledge, which results in these errors. In other words, their previous knowledge is unable to serve as a foundational material for generating ideas in solving new problems encountered. These new problems related to trigonometry are used not only to apply previously acquired knowledge to the issues at hand but also to learn new mathematical concepts. Consequently, numeracy problems become a solution for students to study mathematics coherently.

Article History
Received: 30-06-2023
Revised: 28-07-2023
Accepted: 21-08-2023
Published: 16-09-2023

Key Words:
Field Independent; Thinking Process; Numeration; Student Errors.

How to Cite: Alfarisi, S., As'ari, A., & Sukoriyanto, S. (2023). Causes of Student Errors in Solving Numeration Problems : A Case Study on Students with a Strongly Field Independent Cognitive Style. *Jurnal Kependidikan: Jurnal Hasil Penelitian dan Kajian Kepustakaan di Bidang Pendidikan, Pengajaran dan Pembelajaran, 9*(3), 1050-1059. doi:https://doi.org/10.33394/jk.v9i3.8673

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Introduction

Students' thinking process has a very important role in answering a numeracy problem. Maharani et al. (2019) and Arifani et al. (2017) stated that knowing the thinking process of students when solving a problem is important and must be done by the teacher. By knowing students' thinking processes, teachers can get an overview of students' thoughts when processing or processing information, knowing the extent of understanding of the material that has been learned, seeing students' strategies and potential in solving problems and understanding student difficulties, which will be very beneficial for the next learning process (Handayaningsih & Nusantara, 2021). Saraswati & Agustika (2020) added that a teacher can develop students' thinking skills after knowing students' thinking processes, and teachers can guide students in developing critical thinking skills so that students are able to face the challenges of the 21st-century as well (Tumanggor, 2021). Two of the four 21st-century skills, namely critical thinking and creative thinking, are a strong impetus for teachers to know students' thinking processes (As'ari et al., 2019).

The encouragement of critical and creative thinking can be facilitated through the thought process of solving numerical problems (Supriadi et al, 2015); (Ariefia et al, 2016); (Purwanto et al, 2019) There is a tendency to teach mathematical thinking and the existence of critical and creative thinking skills. Subanji & Supratman (2015) explained in their research that when students think in problem solving, there is a process between incoming new information and changes in the schema (cognitive structure) in the student's brain. This is because the problem solving given is not a routine problem faced by students, so new strategies and knowledge are needed to find solutions (Kurniawan et al., 2017). Someone who is accustomed to thinking will be able to see his thoughts in his behavior, but he cannot directly see his thinking process when facing a problem. According to Hidayanto (2013) the thinking process can be observed based on the answers given in problem solving, according to Sapti et al. (2019) the thinking process can be observed through the results of their work, and according to Wardhani & Subanji (2016) the thinking process can be done by asking students to mention the steps in their minds. Sternberg & Sternberg (2013) stated that the thinking process that occurs in a person experiences three steps, namely (1) Formation of understanding, (2) Formation of opinion, and (3) Drawing conclusions. In each step of solving mathematical problems, the thinking process that will be experienced by a person is generating ideas, clarifying ideas, assessing the reasonableness of ideas, and complex thinking tasks (Swartz et al., 1998).

The student's thinking process is influenced by the level of understanding and mastery of the student's concept of problem solving. Mathematical problem solving is closely related to the thinking process (Liljedahl et al., 2016; Schoenfeld, 1982). Students' thinking processes can be traced with several reviews based on Polya's steps in solving mathematical problems, namely understanding the problem, planning the solution, implementing the solution and looking back (Hardianto, 2017). Systematic steps are needed in solving math problems. Based on what Polya (1973) and Hayuningrat & Listiawan (2018) stated, the solution steps are understanding a problem, planning the solution of the problem, implementing the planned plan, and looking back at the solution of the problem for examination. At the stage of re-examining the answer can foster positive effects on problem solving skills (Kevin & Roble, 2021). Mathematical problems given are usually in the form of problems. However, the problems given by teachers to students are not all mentioned problems. If students can solve easily, then the problem is not a problem for students (Muliawati, 2016). Hudojo (2005) states that something is said to be a math problem if (1) It is challenging to solve and can be understood by students, (2) It cannot be done with routine procedures that students have mastered, and (3) It involves mathematical ideas. The problems given in mathematics learning activities should be non-routine problems. Non-routine problems in mathematics are problems whose solutions cannot be solved procedurally (Baroody & Coslick, 1993). This means that non-routine problems in solving require structured stages and require a relatively longer time to solve (Muliawati, 2016).

Students have different thinking processes from one another. This is because each individual has different abilities and potential (Amir, 2013). Students' cognitive style is one of the things that allows differences in the thinking process of students (Mirlanda et al., 2020). In line with research conducted by Ngilawajan (2013) found that each student has the ability, way, and style of thinking that is not the same in solving math problems. The difference between each student is called cognitive style. Cognitive style is how individuals collect, process, and evaluate data that can affect the individual in observing, organizing, and providing an interpretation of information (Allinson & Hayes, 1996). Cognitive style is divided into two parts, namely field-independent and field-dependent (Witkin et al., 1977). To distinguish individuals who have that cognitive style is by using the Group Embedded Figured Test commonly referred to as GEFT (Oh & Lim, 2005).

Based on the results of this study, there were 20 students who were given a Group Embedded Figured Test (GEFT) question sheet. After the results were obtained, researchers conducted interviews with mathematics teachers who teach in class XI to determine the

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https://e-journal.undikma.ac.id/index.php/jurnalkependidikan/index

Vol. 9, No. 3 : September 2023
E-ISSN: 2442-7667
pp. 1050-1059
Email: jklppm@undikma.ac.id

research students who will be given numeracy questions to students with Strogly FI cognitive style. Numeracy test questions given are questions that have been adapted from the Center for Educational Assessment (PUSMENDIK). The results of the work done by students will be presented in Figure 1.

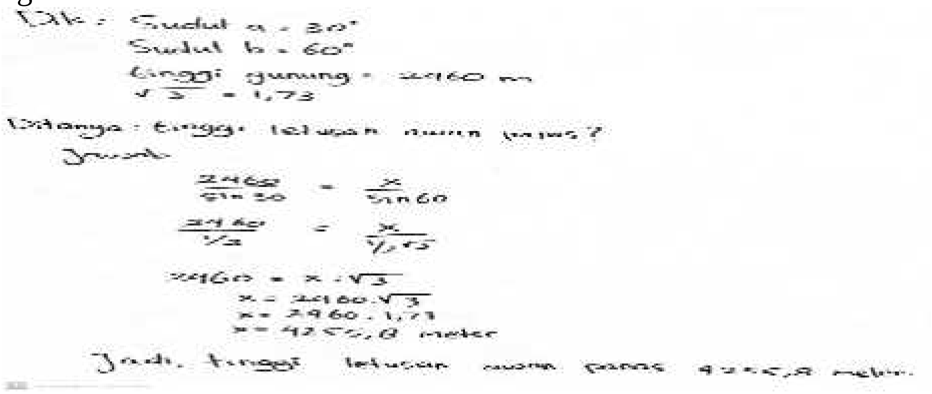

Figure 1. Student Work

From the results of student work, it was found that one student was wrong in understanding and applying the concept of trigonometry in working on the problem, which caused the process of obtaining the results to be wrong. So, the conclusion obtained by the student in solving the problem is also wrong. In addition, students are also wrong in performing calculation operations. This contradicts the research of Wulan & Anggraini (2019), which explains that field-independent cognitive style students in solving the problems given, can solve the problem correctly, both in understanding, organizing a plan, implementing a plan and looking back. Therefore, it is interesting to examine the discussion of the thought process of field-independent cognitive style students who experience errors in solving the given problem to explore the causes of errors that occur in solving the given problem. Wulan & Anggraini (2019) explained that students with field-independent cognitive style were able to solve the given problem correctly. This is very inversely proportional to the data findings in pre-research; one of the students with a field-independent cognitive style tends not to be able to solve the problems given (in this case, numeracy problems) correctly. As for the purpose of this study aims to reveal the causes of errors in solving numerical problems related to trigonometry in students with a strongly field-independent cognitive style.

Research Method

This research approach uses qualitative research, because researchers directly examine the phenomena experienced by research students directly, in detail and in depth by describing these phenomena in the form of language words (Moleong, 2016). The qualitative approach in this study is to find out the students' thinking process in solving problems in depth, then describe the thinking process in detail (Creswell, 2012). The research method used is case studies to describe the thought process of field-independent cognitive style students who experience errors in solving the problems given and explore the causes of these students experience errors in solving the problems given.

This research was conducted at MA Ibadurrochman Malang in the odd semester of the 2022/2023 academic year. The class selected in this study was class XI IPA. The process of determining students is done by giving a test sheet called GEFT (Group Embedded Figure Test) to 20 students. After getting the GEFT test results, students were selected based on the GEFT test results with the highest scores. The instrument in this study consists of the main instrument, namely the researcher himself and supporting instruments consisting of GEFT sheets (Group Embedded Figure Test) and Numeration Problem Solving Test Sheets (TPMN)

Vol. 9, No. 3 : September 2023
E-ISSN: 2442-7667
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and interview guidelines. The numeracy problem solving test question consists of two problems: the first problem is a problem that has been done before, and the second problem is a problem that has never been done before. The data collection techniques carried out are validating the instruments that have been made, giving the GEFT test sheet, giving the TPMN sheet, then the final stage of the interview process. This data analysis technique is called interactive model analysis (Miles & Huberman, 1994).

Results and Discussion

Results of Student Work in Answering Questions

Step I. Understanding the Problem

The data source obtained by the researchers is the work data written by SFI and the transcribed interview data with SFI. At the idea generation stage (GI), the subject reads the problem from the beginning and looks at the picture contained in the problem, then writes down what is known and what is asked in the problem. The following is written evidence of SFI's work that shows the initial data in solving numerical problems presented in Figure 2.

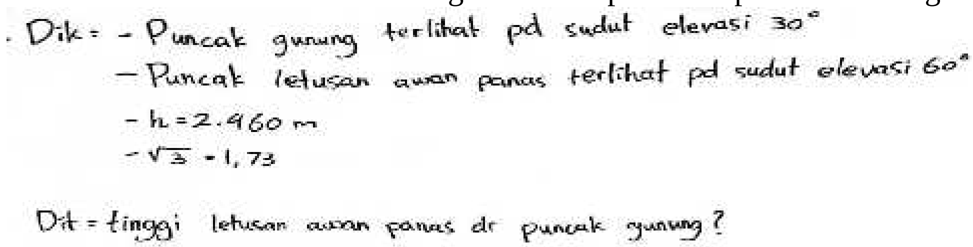

Figure 2. SFI's initial statement in solving Problem Number 1

At the stage of clarifying ideas (CI), SFI explained the meaning written in the known and asked parts of the problem through. At the stage of assessing the feasibility of ideas (AI), the researcher conducted an interview on the work done by SFI. SFI saw a connection between the known part and the questioned part of the problem. The known parts will be used to find the height of the hot cloud eruption from the top of the mountain. At the complex thinking (CT) stage, SFI decided that the known part was enough to answer the question.

Step II. Planning for Completion

At the idea generation (GI) stage, SFI observed the known and questioned parts of the problem to explore the relationship between what is known and what is asked in the problem, and whether the known information is sufficient to answer what is asked in the problem. Furthermore, SFI has an idea to solve the problem written on the sheet in Figure 3.

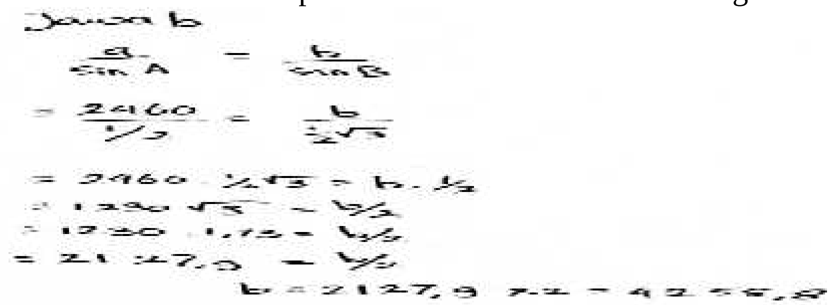

Figure 3. SFI's Problem Solving Number 1

At the stage of clarifying ideas (CI), SFI explained the idea used in solving problem number 1. SFI had explained in the interview that SFI used the sine rule formula in solving the problem because SFI saw that in the picture contained in problem number 1 there were two angles and one side facing one of the known angles. At the stage of assessing the feasibility of ideas (AI), SFI used the link between the known part and the part asked in the problem. At

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Vol. 9, No. 3 : September 2023
E-ISSN: 2442-7667
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the complex thinking (CT) stage, SFI made a decision that the method or idea that was thought of could be used to answer what was asked in the problem.

Step III. Implementing the Solution Plan

The results of the subject's work in solving problem number 1 can be seen in Figure 4.

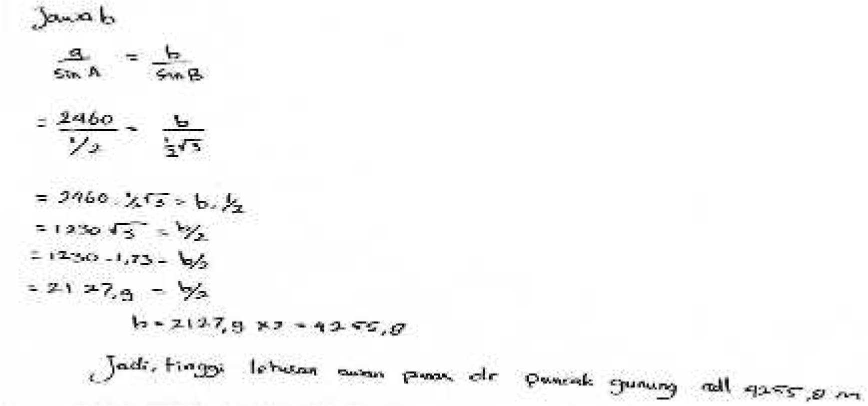

Figure 4. Subject's work in solving Problem Number 1

At the idea generation stage (GI), SFI saw the relationship between what was known and what was asked in the problem and related it to the material and problems she had learned before, so SFI decided to use the sine rule. At the stage of clarifying ideas (CI), SFI explained each step of the solution listed in the worksheet in Figure 4. At the stage of assessing the feasibility of ideas (AI), SFI explained the basics of his thinking in generating a solution idea in the worksheet in Figure 4. At the stage of complex thinking (CT), SFI carried out the final problem solving of the given problem and drew conclusions on the problem.

Step IV. Relooking

At the stage of generating ideas (GI), SFI did not go through the stage of generating ideas at the step of looking back. In the interview process, SFI explained that SFI immediately collected when he had finished working on the problem. At the stage of clarifying ideas (CI), SFI also did not experience the stage of clarifying ideas at the step of looking back. At the interview stage, it was known that SFI was sure of the answers that had been done on the answer sheet. At the stage of assessing the feasibility of ideas (AI), SFI responded that the answer given was based on what had been obtained from the teacher who taught it. At the complex thinking (CT) stage, SFI thought that the answer was correct because it used the sine rule, which she concluded based on the process of observing the picture in the problem.

Students in solving problem number one experience errors in the step of understanding the problem, in line with Saparwadi's research (2022) which states that students tend to be wrong in understanding the problem when solving story form problems. Kristofora & Sujadi (2017) state that the biggest mistake often made by students is mistakes in the stage of understanding the problem. As well as in Farida (2015), students tend to experience problems at the step of understanding the problem and understanding the concepts that will be used in solving a problem. In the step of understanding the problem in this study, students made mistakes in understanding the meaning contained in the problem, namely by assuming that the problem in number one consists of a triangle with two known angles and one side, one of which is opposite the known side that will be used in solving the problem to be used. In addition, students missed important information contained in the problem, namely the length of the side of the mountain peak seen at an elevation angle of 30° is the same as the length of the side of the peak of the hot cloud eruption seen at an elevation angle of 60°. This is because students are less careful in observing the picture and are not careful in reading the problem, so they miss important information contained in the problem. This statement is supported by research conducted by Sunarsi (2009) and Marasabessy et al. (2021), which states that students' errors in understanding a problem are caused by students' inaccuracy in observing images and not being careful in reading problems, resulting in missing important information contained in the problem. Students' inaccuracy in reading problems and observing images can cause errors in understanding a problem. If students do not read the problem carefully, they may not understand the instructions and important information needed to solve the problem. Similarly, if students do not observe images carefully, they may miss important information or details needed to understand the problem. reading comprehension skills play an important role in students' success in solving mathematical problems (Lin & Powell, 2022).

Some researchers such as Yoğurtçu (2013), Potter (2012), Vitale & Romance (2012) have discussed the significant impact of students' reading problems including, (1) Difficulty understanding instructions: Students who are not careful in reading the questions will have difficulty in understanding the instructions given in the questions. This can make them answer the question incorrectly or give incomplete answers. (2) Difficulty understanding the context of the problem: Students who are not careful in reading the question may also have difficulty understanding the context of the question. This may lead them to answer the question incorrectly or give irrelevant answers. (3) Wasted time: Students who are not careful in reading the question may also waste time understanding the question. This can lead to them running out of time to answer other questions that may be easier or give more appropriate answers.

Students in the step of planning the solution experience errors in determining the formula to be used. Students choose to use the sine formula rule. This causes students to experience errors in using concepts. This is because prior knowledge can't be used as a basis for generating ideas in solving new problems encountered. This is in accordance with research (Rofi'ah et al., 2019). Based on the interview, it is known that students use the rules in the sine formula because in the problem there are two known angles and one side, in this case, students assume that in the picture there is only one triangle and the problem is similar to the problems that have been given by the teacher. If observed better, there are two triangles used in the problem, namely a triangle with an angle of 60° and a triangle with an angle of 30°. And students have been wrong in the step of understanding the problem, especially at the complex thinking stage. That is, students do not observe that the length of the side of the mountain peak seen at an elevation angle of 30° is the same as the length of the side of the peak of the eruption of hot clouds seen at an elevation angle of 60°. Thus adding to the list of errors owned by students.

In the interview process, it is known that students tend to be less careful in solving the problems given and students tend to use the fastest way in solving the problems given only because students see in the problem there are only two known angles and one side. Even after being confirmed through the interview stage, students determine the formula used only by looking at two pictures and one side and one known angle facing the side. In this case, students make mistakes due to inaccuracy and due to their carelessness in determining the formula to be used only by paying attention to the picture in the problem. This is because prior knowledge can't be used as a basis for generating ideas in solving new problems encountered. Some of the causes of errors experienced by students are too hasty in determining the formula to be used.

This is supported by research conducted by (Setiawan, 2020), who stated that one of the causes of errors made by students is rushing to answer the problems given. Students who

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E-ISSN: 2442-7667
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are in a hurry to solve problems can cause them to answer problems incorrectly. When students are in a hurry, they may not pay attention to important details in the problem, such as keywords, instructions, or relevant information. As a result, they may make mistakes in interpreting and answering the problem. In addition, when students are in a hurry, they may not take the time to think through and consider answer options properly before choosing an answer. This may result in them choosing the wrong answer or not fully understanding the concepts or information needed to answer the question.

In the step of implementing the solution plan, students have experienced errors in the step of planning the solution plan. This resulted in students being wrong in order to implement the solution plan. This statement is in accordance with the research of Nadhifa et al. (2019). In their research, they stated that students who experience errors in planning solutions tend to experience errors in implementing the solution plan. Problem solving plans are steps or strategies planned in advance to solve a particular problem. If the solution plan is wrong or inappropriate, then the steps taken to implement the plan are likely to be wrong or ineffective.

In the step of looking back, students do not re-examine the solution obtained, and do not perform calculations again. In line with research conducted by Hidayah (2016). When students do not re-examine the solution that has been obtained, it can cause errors in working on problems. When solving math problems, students often make mistakes at the verification or solution-looking stage. Students who are in a hurry or less thorough can get stuck in the habit of accepting the first answer that comes to their mind and immediately continue without relooking or looking back at the problem. Research students in clarifying ideas how to write every plan that has been planned before as in question number 1 part "substituting "$\frac{a}{\sin A} = \frac{b}{\sin B}$" to "$\frac{2460}{\frac{1}{2}} = \frac{b}{\frac{1}{2}\sqrt{3}}$" to the stage of "simplifying the equation "2127,9=$\frac{b}{2}$", to "b=2127,9x2=4255,8". As well as in problem number 2 part "substituting the value of "a" which is known in the problem in the form of an equation "$\frac{a}{\sin A} = \frac{b}{\sin B}$" to "$\frac{1.800}{\sin 60^\circ} = \frac{b}{\sin 45^\circ}$" to the stage of "substituting the value of "b" and the value of "a" into the equation "$s = a + b$". Research students in assessing the reasonableness of ideas by concluding that what is written on the answer sheet is in accordance with what was planned previously and has been in accordance with what they have obtained in previous learning. Furthermore, research students in complex thinking decided that the information known in the problem was sufficient to answer the part that was asked.

Conclusion

The conclusion obtained from the results of this study is that students in solving numeracy problems experience the stages of generating ideas, clarifying ideas, assessing the feasibility of ideas, and complex thinking in Polya's problem solving steps. However, at the re-examination stage in solving problem number 1 with the criteria for problems that have been done before, students do not experience the idea generation stage and the idea clarification stage. And the research shows that the cause of student errors in solving numerical problems is that the source of prior knowledge causes more errors, in the sense that prior knowledge is not able to become an idea-building material in solving new problems encountered. This new problem related to trigonometry is used not only to apply the concept of prior knowledge to the problem at hand, but to learn new mathematical ideas. Thus, numeracy problems become a solution for students to learn mathematics coherently.

Recommendation

Recommendations based on the results of this study are for teachers, teachers must often remind students that solving the mathematical problems given must be done more carefully and not in a hurry to solve the problems given. And teachers remind students to often train themselves to solve mathematical problems.

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