A Metacognitive Profile of Vocational High School Student’s Field Independent in Mathematical Problem Solving

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Abstract. The study was designed to discover examine the profile of metacognition of vocational high school student of the Machine Technology program that had high ability and field independent cognitive style in mathematical problem solving. The design of this study was exploratory research with a qualitative approach. This research was conducted at the Machine Technology program of the vocational senior high school. The result revealed that the high-ability student with field independent cognitive style conducted metacognition practices well. That involved the three types of metacognition activities, consisting of planning, monitoring, and evaluating at metacognition level 2 or aware use, 3 or strategic use, 4 or reflective use in mathematical problem solving. The applicability of the metacognition practices conducted by the subject was never at metacognition level 1 or tacit use. This indicated that the participant were already aware, capable of choosing strategies, and able to reflect on their own thinking before, after, or during the process at the time of solving mathematical problems. That was very necessary for the vocational high school student of Machine Technology program.

1. Introduction
The study results of the Trends in International Mathematics and Science (TIMSS) revealed that the questions used to measure the ability of learners fall into four categories: (1) low to measure ability up to the knowing level, (2) intermediate to measure ability up to the applying level, (3) high to measure ability up to the reasoning level, (4) advanced to measure ability up to the reasoning level with incomplete information. While the achievements of Indonesian children as revealed in several TIMSS reports were less encouraging, 95% of the Indonesian children were only up to the intermediate level, while almost 40% of the Taiwanese learners are able to reach high and advanced levels by Kemendikbud [1]. This shows that the mathematical ability of the Indonesian children was very low, especially in terms of mathematical problem solving. The low level of mathematical problem solving ability of the Indonesian in general, particularly the vocational high school student of Machine Technology Program (known as SMK Pemesinan) in East Java should be improved.

The problem-solving stage that this study refers is one proposed by Polya [2]. Polya in [2] suggested the detailed steps that should be taken by students so that problem solving can be done effectively and efficiently and obtain the right solution. Polya's problem-solving steps direct student to always be aware of their potential abilities and able to manage those abilities to be used in problem solving. Polya problem-solving steps is understand the problem, devise a plan, carry out the plan, look back.

Some researchers have pointed out that metacognition is an important issue in problem solving as well as in the acquisition and application of learning skills in various fields of discovery by Flavell in [3], Panoura and Philippou, 2005 in [4]. One advantage of involving metacognition processes in solving trigonometric math problems is to establish a strong, thorough and profound understanding of trigonometric math problems. This enables the student of vocational high school student of Machine
Technology Program (SMK Pemesinan) to not only use the formulas, but also are aware of the process and the results of their thinking about the meaning and usefulness of the trigonometric formulas. It is very necessary by the students of to solve mathematical problems, in particular trigonometry serving as a support for other participant. So it is expected to improve the quality of education in vocational high school student of Machine Technology Program (SMK Permesinan) in East Java Indonesia.

Acharya in [5] cited that if the cognitive style of student can be accommodated in learning, it will result in improving learning attitudes and increasing thinking skills, academic achievement, and creativity. Information about cognitive styles can help teachers at school become more sensitive to the differences the student have in the classroom. Therefore, by knowing the cognitive styles of learners, the teacher knows the right way to teach in the classroom.

Many scholars argue [3,4,6,7,8,9] about the notion and components of metacognition, but essentially they put an almost equal emphasis on the components. This study therefore only focused on metacognition experience component which includes planning, monitoring, and evaluating. If one can evaluate the process and result of thinking, it will allow increasing awareness about process and result of one's thinking and ultimately will increase his or her learning results.

Swartz and Pepkins [8] distinguish the four levels of metacognition: tacit use, aware use, strategic use, and reflective use which is the development of metacognition ability. The tacit use or level 1 is the level of one's metacognition with the indicator: not thinking about the decision taken or the thinking process it does. The aware use or level 2 is the level of metacognition of a person with the indicator: aware of what and why doing a particular thinking. The strategic use or level 3 is the level of one's metacognition with the indicator: having the ability to regulate their own thinking, consciously using specific strategies that improve the thinking accuracy. The reflective use or level 4 is the level of one's metacognition with the indicator: having the ability to reflect on his own thinking before, after or during the process and thinking about how to proceed and how to improve.

Witkin in [10] stated that cognitive style is a characteristic that is reflected from each individual and these characteristics can be influenced by two factors, namely: the factors related to the influence of external stimuli and the factors related to the influence of an individual person. Witkin in [11] described the characteristics of the cognitive style of the Field Independent are (a) analytical, competitive, independent, and individualistic, (b) having its own goals, objectives, strategies and reinforcement, (c) intrinsically motivated, (d) less social skills and preferring individual tasks, (e) structured and well-organized in learning.

Based on this above-mentioned problem, it is important for the student of SMK Permesinan who are highly capable and cognitive field independent to realize knowledge of their metacognitive ability. The goal is to be able to solve mathematical problems either in the field of mathematics itself or its application in the subject matter specialization in line with each area of expertise.

2. Research Method

2.1 Research Type
The type of this research is explorative with qualitative approach. To get in-depth descriptive data about the metacognition profile of the SMK Pemesinan student with high-cognitive and field-independent cognitive techniques in solving trigonometric mathematical problems, the student are given the tasks of solving mathematical problems (TPM-1) followed by interviews. At the time of the interviews, the student are asked to explain the problem solving done in accordance with the steps of solving the problem according to Polya. The data of the problem solving tasks and the interviews were combined, then described qualitatively and the results were in the forms of written or oral words or descriptions of the research participant and then analyzed. Therefore this research used a qualitative descriptive approach.
2.2 Research Instruments
In addition to the researcher as the main instrument in this research, other instruments such as mathematical ability test (known as TKM), Group Embedded Figures Test (GEFT) test, problem solving test (known as TPM-1), and interview guidelines were needed.

The sample problem solving test is presented as follows: note Figure 1

![Figure 1](image)

**Figure 1.** Figure mathematical ability test (TPM).

A large circle $L_1$ with a diameter of 14 cm and a small circle $L_2$ has a diameter of 10 cm. If it is known that the length of the tangent line of the outer alliance of the two circles is $AC = BD = 50$ cm, then specify the magnitude of $\angle APB$.

2.3 Participant
The participant of this study was a tenth-grade student of SMK Permesinan. The basic consideration is that mathematics is the foundation of support for most other participant taught in SMK Permesinan in the tenth, eleventh, or twelfth grades. Based on the 2013 curriculum in [12] the trigonometric materials were taught in SMK Permesinan. Some criteria of the participant of this study were a high-ability student with field independent cognitive styles. Theme was only one student participating in this study.

The criteria for the selection of research participant include: (1) the mathematical ability test (TKM) scores by taking participant from high-ability groups. The participant is regarded as highly capable, if the scores $> 80$, (2) GEFT scores, the student's abilities are divided into two cognitive style groups in [10]: (a) high-ability students, if their GEFT scores $> 9$ and the students belong to a group of highly capable cognitive field-independent participant, (b) for highly-skilled students, if their GEFT scores are between 0-9 then the students include high field-dependent cognitive skills, (3) if from 2 categories in (2) .a) there is at least one subject that meets, then the next step is to ask the teacher's judgment about whether the selected participant has a score that corresponds to the day-to-day ability of his class and can express his oral and written opinions. The selected participant is known as TFI.

3. Results and Discussion
Based on the results of TFI subject analysis in solving mathematical problems starting from the stage of understanding mathematical problems of TPM-1, creating a mathematical problem solving plan of TPM-1, implementing mathematical problem solving of TPM-1, and reviewing the results of mathematical problem solving of TPM-1, it can be concluded that the metacognition profile conducted by TFI subjects in solving the problems of trigonometry of TPM-1 by considering the frequency of metacognition activity implementation at each stage and level is presented in table 1.
Table 1. Implementation of TFI Metacognition Activities Implementation In Trigonometry Problem Solving (TPM-1)

| Problem Solving Stages                       | Metacognition Stages and Levels | Planning | Monitoring | Evaluating |
|----------------------------------------------|---------------------------------|----------|------------|------------|
|                                              | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| Understanding problems                        | 0 | 2 | 0 | 0 | 0 | 1 | 1 | 5 | 0 | 1 | 1 | 1 |    |    |    |    |    |    |    |    |    |    |    |    |
| Problem solving planning                      | 0 | 0 | 1 | 2 | 0 | 0 | 1 | 5 | 0 | 2 | 1 | 1 |    |    |    |    |    |    |    |    |    |    |    |    |
| Implementing the problem solving planning    | 0 | 2 | 0 | 0 | 0 | 1 | 5 | 5 | 0 | 2 | 2 | 4 |    |    |    |    |    |    |    |    |    |    |    |    |
| Reviewing the problem solving results         | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 2 | 2 | 0 |    |    |    |    |    |    |    |    |    |    |    |    |
| Total                                        | 0 | 4 | 1 | 2 | 0 | 2 | 8 | 15| 0 | 7 | 5 | 6 |    |    |    |    |    |    |    |    |    |    |    |    |

From Table 1, the results of metacognition process analysis conducted by TFI in the TPM-1 trigonometric problem solving was in the TFI planning stage at the metacognition level 2 or aware use, 3 or strategic use, and 4 or reflective use. Specifically, with four items at level 2 or aware use, this indicated that TFI was aware of what and why doing certain thoughts at the understanding problem stage, and executing the problem-solving plan. There was one item at the metacognition level 3 or strategic use, it indicated that TFI could regulate its own thinking and consciously use specific strategies that improved the accuracy of thinking at the planning stage of making problem-solving plans. There were two items at the metacognition level 4 or reflective use, it indicated that TFI had the ability to reflect on its own thinking before, after or during the process and thinking about how to proceed and how to improve in the planning phase of making a problem-solving plan. From table 1 above, TFI did not do planning at the reviewing problem solving result but directly did monitoring and evaluating.

At the monitoring stage TFI was at the metacognition level 2 or aware use, 3 or strategic use, and 4 or reflective use. There were two items at the metacognition level 2 or aware use, this indicated that TFI was aware of what and why do certain thoughts scattered at the monitoring stage when understanding the problem, and executing the TPM-1 trigonometric problem-solving plan. There were a total of 8 items at the metacognition level 3 or strategic use, this indicated that TFI could regulate its own thinking and consciously use specific strategies that improved the accuracy of its thinking at the monitoring stage when understanding the problem, making problem-solving plans, implementing problem-solving plans, and reviewing TPM-1 problem solving results. There were a total of 15 items at the metacognition level 4 or reflective use, it indicated that TFI had the ability to reflect on its own thinking either before, after or during the process and thinking about how to proceed and how to improve during the monitoring phase of problem solving, making problem-solving plans, and implementing a TPM-1 trigonometric problem-solving plan.

At the evaluation stage TFI is at metacognition level 2 or aware use, 3 or strategic use, and 4 or reflective use. With 7 items at the metacognition level 2 or aware use, this suggested that TFI was aware of what and why do certain thoughts scattered at the stages of understanding problems, creating problem-solving plans, implementing problem-solving plans, and reviewing the results of TPM-1 trigonometric problem solving. As there were 5 items at the metacognition level 3 or strategic use, it revealed that TFI could regulate its own thinking and consciously use specific strategies that improved the accuracy of its thinking at the evaluating stages when understanding problems, making problem-solving plans, implementing problem-solving plans, and reviewing problem-solving results. As there were 6 items at the metacognition level 4 or reflective use, it showed that TFI had the ability to reflect on its own thinking before, after or during the process and thinking about how to proceed and how to improve at the evaluating stages of understanding the problem, making problem-solving plans, and implementing a TPM-1 trigonometric problem-solving plan. Table 1 showed that TFI was never at the metacognition
level 1 or tacit use, it pointed out that TFI had not never thought of decisions made on the thinking process either in the contextual or formal problem solving.

These results showed that high-ability subject with independent field cognitive style performed the metacognition activities well involving the three types of metacognition activities, i.e. planning, monitoring, and evaluating at the metacognition level 2 or aware use, 3 or strategic use, and 4 or reflective use in mathematical problem solving. This is in contrast to the research of Mania Nosratinia, and Shirin Adibifar [13]. The results showed that both experimental and control groups were both given the pretest of writing. The experimental group received the metacognitive strategy training, while the control group received a regular teaching program at a language school. At the end of the training, both groups were given a post-test and the results showed that the experimental group was statistically better in their post-tests. In addition, the independent-field learners outperformed the dependent-field groups in their post-tests. The results of Maria Nosratinia and Shirin Adibifar showed that the metacognition training on writing skills while solving mathematical problems had not been explored, the metacognition profile thus needed to be revealed in solving mathematical problems.

In addition, the research results by Agoestanto, Sukestiyarno and Rochmad in [14] showed that the students' mathematical critical thinking skills with FI cognitive style were better than the ones of FD cognitive style to conclude, assumptions, deductions, and interpretations. While in the aspect of evaluation of argument, the students' critical thinking abilities with FD cognitive style were better than the one of students with FI cognitive styles. The results of Agoestanto's study show only the critical thinking skills of FI and FD students only, but had not shown the metacognition profile of the subjects. Thus the metacognition profile needed to be revealed.

The research by Effendi in [15] concerning "Implementation of Creative Problem Solving Model to Improve The High School of Student's Metacognitive indicated that (1) improvement of metacognitive ability of students who applied the Creative Problem Solving model was significantly better than the one of the students who only employed the conventional learning; (2) There were significant differences in metacognitive enhancement abilities among the students who obtained the creative problem-solving models and one of the students who received the conventional learning in terms of previous, high, middle and low student mathematics levels. There was an increase in metacognitive ability of the experimental class students who previously had high and moderate mathematical skills, it was significantly better than students' metacognitive abilities in the control class. However, the increased metacognitive ability of the lower students and the level of prior mathematical knowledge in the experimental and control classes did not differ significantly. In this study the students' metacognition abilities given the creative problem solving were increased, but not yet explained on the level of metacognition to what extent the improvement was. In addition, the cognitive styles that considerably affected the learning outcomes were also not discussed in the research by Effendi. It therefore needs to be further investigated concerning the levels of metacognition and the cognitive styles.

4. Conclusion

The result of this research revealed that the subjects of TFI carried out the metacognition activities with very high frequency and dynamic. TFI's metacognition activities involved the three types of activities: planning, monitoring, and evaluating already at the metacognition level 2 or aware use, 3 or strategic use, and 4 or reflective use in solving mathematical problems. The frequency of metacognition activities done by the subjects of TFI, never at the metacognition level 1 or tacit use. This suggested that the subjects of TFI already had consciousness, was able to choose a strategy, and was able to reflect on their own thinking either before, after, or during the process of solving trigonometric problems. The implementation of good metacognition activities when solving trigonometric math problems is necessary for machining vocational students.
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Acknowledgements

The author would like to thank the Ministry of Research and Technology who have granted the scholarship to the author.