Development of Self-Evaluation Instrument in the Implementation of PME (Planning-Monitoring-Evaluating) Learning Model to Evaluate Metacognitive Performance

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***Abstract*---This study aims to develop a self-evaluation instrument used to measure the achievement of metacognitive performance, especially in the implementation of PME learning model. The development design used is R & D design model from Thiagarajan but modified to *"3-D"* (Define, Design, and Develop). The approach used is a mix-methods approach. A qualitative approach is carried out through literature review, then tested through expert validation. While the quantitative approach is carried out through experimental studies, to analyze the validity and reliability of the measurement model can be done with *LISREL*. The research subjects consisted of 128 students from four high schools in Brebes Regency. From the results of this study were obtained: (1) the instrument developed was stated to be good with little revision; (2) the results of the validity test show that only the 21st indicator has a *standardized loading factor* = 0.46 < 0.5 or invalid, which means all indicators are valid except the 21st indicator; and (3) the reliability test results obtained by *CR* ≥ 0.70 and *VE* ≥ 0.50, which means the instrument has a good level of reliability. So this self-evaluation instrument is feasible to use to evaluate metacognitive performance on PME learning model.**

Keywords: Self-Evaluation Instrument, PME Learning Model, Metacognitive Performance

I. INTRODUCTION

Metacognition is a person's performance achievement, so that metacognition can be measured or assessed for its success or failure. Metacognition regulatory competence can be assessed through planning, monitoring, and evaluation activities, because all three can improve the performance of cognitive resources (Schraw & Moshman, 1995). To achieve metacognitive situations in learning, it is necessary to implement metacognitive strategies, namely regular processes used to control cognitive activities, and to ensure that cognitive goals are met (Ghasempour *et al.*, 2013; TEAL, 2012).

Ku & Ho (2010) and Ghasempour *et al.*, (2013) recommend the use of metacognitive strategies through metacognitive activities, namely planning, monitoring, and evaluating, so that the qualitative analysis of the use of metacognitive strategies is studied through three dimensions, namely the planning dimension, the monitoring dimension, and the evaluating dimension. More specifically, Amin and Mariani (2017) recommend the use of the PME (Planning, Monitoring, Evaluating) learning model to improve the metacognitive performance of students.

In mathematics learning, the use of metacognitive strategies can overcome problems, especially in helping improve students' attitudes towards mathematics (Du Toit, 2009), so that students need to be encouraged to develop metacognitive strategies within the constructivism learning framework (Ghasempour *et al.*, 2013), including by do self-evaluation. The self-evaluation approach is carried out by involving individuals as direct sources of information about themselves (Athanasou, 2005). Self-evaluation can be used in the metacognition literature to refer to assessments made by individuals on the basis of self-knowledge (Ross, 2006).

One of instrument that has been recognized as a reliable indicator of metacognition is the *LASSI (Learning and Study Strategies Inventory)*. LASSI presents three main components of a learning strategy which include skills, desire, and self-policy in learning strategies (Downing, 2009). Meanwhile, the self-evaluation instrument in the PME learning model is designed to control the activities of the metacognitive learning strategy, namely activity planning, monitoring, and evaluating.

II. RESEARCH METHODS

The scope of this research is the development of self-evaluation instruments that are used to control the implementation of the PME learning model. The instrument was made in the form of a self-evaluation questionnaire on planning, monitoring and evaluating activities. The indicators developed specifically describe the implementation of planning, monitoring and evaluating activities. The research design used in this study was the Thiagarajan R & D model that was modified in *3-D (Define, Design, and Develop)*. The approach used is a mix method approach (quantitative-qualitative). A qualitative approach was used to design the initial design and then to test the instrument validation by three expert validators and one practitioner validator. While the quantitative approach is carried out through instrument testing, then testing the validity and reliability testing.

The test was carried out on 128 students from four high schools in Brebes Regency. Validity analysis is done by checking the value of *the standardized loading factor (λ)* of the observed variables, where the indicator is valid if the value is ≥0.50. While the model reliability analysis is obtained by calculating *the value of construct reliability (CR)* and *variance extracted (VE)* from the values of standardized loading factors and error variances. A construct has good reliability if the *CR* value is ≥0.70 and the *VE* value is ≥0.50. Indicators of success in this study are instruments developed that meet valid criteria and reliable criteria.

The procedure for developing a self-evaluation instrument with regard to the completeness of the components and the objectives of developing a self-evaluation instrument. The completeness of the components of this self-evaluation instrument includes: (1) identity; (2) instructions; (3) the instrument being measured; and (4) achievement indicators. While the purpose of developing this instrument is to measure the weight of the metacognitive behavior activities carried out by students, so that this instrument is developed by taking into account: (1) the characteristics of students; (2) use verbs that are operational and measurable; (3) use language that is easy for students to understand; and (4) adjusted to the goals to be achieved (accustomed to metacognitive behavior in mathematics learning).

III. RESULTS AND DISCUSSION

The PME learning model self-evaluation instrument is used to measure and control the implementation of planning, monitoring, and evaluating activities in learning activities that refer to the structure of the PME learning model (Amin & Mariani, 2017) can be seen in Table 1 and the results of the content and construction validation by three expert validators and one practitioner validator can be shown in Table 2.

Table 1. The Results of Developing the Self-Evaluation Instrument of the PME Learning Model (SEI-PME)

Indicators	Sub Indicators
The Planning Activities, namely students' activities in preparing the initial writing (overview) as part of the exploration and elaboration process	
• Completeness of the overview	1. The overview is equipped with a theory of the material 2. The overview is completed with sample questions and discussion 3. The overview is completed with independent question exercises
• Depth of writing	4. Theories and concepts are elaborated in detail and pay attention to mathematical notation 5. The sample content and discussion are elaborately and clearly explained 6. The content of the independent practice exercises is resolved clearly and correctly
• Students' efforts in understandin g and elaborating on writing	7. The overview has read the writing repeatedly 8. The overview reviewed from various sources (references) 9. Content has been discussed with other people (friends or teachers)
• Students' efforts in perfecting writing	10. Ask others to evaluate the writing that was made 11. Record important input from others (friends / teacher) 12. Correct the writing that was stated wrong or altered
The Monitoring Activities, namely the activities of students doing testing and improvement in problem solving activities.	
• Student activities in finding approaches and strategies for solving problems	13. Ability to find approach/strategy 14. Ability to explain arguments on strategies found 15. Ability to find more than one strategy 16. Involved in implementing approach and strategy
• Involvement in collaborative problem solving activities	17. Check/verify the reasonableness of the results and correctness of calculations

	18. Involvement in problem-solving process (testing the allegations) 19. Involvement in collaborative work presentation activities, 20. Respond to input from the environment, 21. Making refinement to improve results, 22. Involvement in activities of drawing conclusions 23. Involvement in preparing written reports.
The Evaluating Activities, namely the activities of students in testing and improving learning activities	
• Students' efforts in making affirmations and justifications (confirmation)	24. Making additional notes 25. Marking important parts 26. Making conclusions about learning outcomes.
• Students' efforts in adding information	27. Searching for and overviewing other reference books, 28. Looking for additional information through internet facilities, 29. Discussing with teacher/peers.
• Students' effort in doing other tasks to further strengthen the mastery of learning competencies to make it more meaningful	30. Doing the questions on their own initiative, 31. Doing the questions with a variety of types, 32. Discussing the questions that have been worked out with friends or teachers.

Table 2. Validation Results of Self-Evaluation Instruments (SEI-PME)

Validator	Validator Assessment	Parts that Need to be Revised
I	Good, with a little revision	Sub-indicators in exploration activities need to be clarified so that they can become habituation for students
II	Good, with a little revision	Pay attention to practicality and readability aspects by students (some sentences need to be simplified to make it easier for students to understand)
III	Good, with a little revision	Pay attention to practicality and feasibility aspects (indicator sentences are made simpler and made as practical as possible)
IV	Very good, with a little revision	The format is made in a form that is more attractive and easy to use

Paying attention to the table above, it shows that the self-evaluation instrument developed was declared fit for use as a research instrument but with little revision. However, the validator gave four special notes on: (1) sub indicators in exploration activities, (2) practicality, readability and usability aspects, and (3) instrument format.

Regarding the sub-indicators of exploration activities, the validator provides suggestions for clarifying the types of exploration activities and can become self-habituation. In the initial draft of the instrument, the sub-indicators of exploration activities only led to the activities of students making overview writing, after being revised the sub-indicators were further developed by adding student activities in writing and exploring examples of questions and discussion, as well as activities of students working on and deepening practice questions independently. By adding this sub-indicator, it is hoped that students will be motivatd to carry out exploration activities with higher quality.

With regard to practicality, readability, and usability aspects, the validator made suggestions for the instrument to be more practical, easy for students to understand, and can be implemented in the learning process. Validators also want the instrument display to be more attractive (not stiff). In the initial draft, the instrument contained three pages and was written in a long sentence, so that the validator considered this instrument to be more practical so that it was easy for students to use and understand. After the revision, the self-evaluation instrument was packaged in tabular form, with simple sentences, made into one page only, and arranged in a more attractive format. The aesthetic value is considered through the selection of letters, layout arrangement (layout), and the addition of "shapes" in certain parts. With this new packaging, it is hoped that the instrument will be easier and more attractive to be used by researchers or other people.

The results of the validity and reliability tests with path analysis with SEM on the self-evaluation instrument tested on 128 students obtained the results as shown in Table 3.

Table 3. Results of the Analysis of the Validity and Reliability of the CFA Model

Laten Variable	Construct (Indicator)	*Error Var*	*Std Loading* ≥ 0.5	Reliability *CR* ≥ 0.7	Reliability *VE* ≥ 0.5	Validity Criteria	Reliability Criteria
	X_1	0.5	0.71			Valid	
	X_2	0.51	0.70			Valid	
	X_3	0.43	0.75			Valid	
	X_4	0.38	0.79			Valid	
	X_5	0.44	0.75			Valid	
Planning	X_6	0.41	0.77	0.92	0.50	Valid	Reliable
	X_7	0.49	0.71			Valid	
	X_8	0.63	0.61			Valid	
	X_9	0.56	0.66			Valid	
	X_{10}	0.45	0.74			Valid	
	X_{11}	0.47	0.72			Valid	
	X_{12}	0.72	0.53			Valid	
	X_{13}	0.27	0.86			Valid	
	X_{14}	0.29	0.84			Valid	
	X_{15}	0.4	0.78			Valid	
	X_{16}	0.29	0.84			Valid	
	X_{17}	0.55	0.67			Valid	
Monitoring	X_{18}	0.41	0.77	0.92	0.52	Valid	Reliabel
	X_{19}	0.5	0.71			Valid	
	X_{20}	0.67	0.58			Valid	
	X_{21}	0.79	**0.46**			Invalid	
	X_{22}	0.47	0.73			Valid	
	X_{23}	0.64	0.60			Valid	
	X_{24}	0.48	0.72			Valid	
	X_{25}	0.56	0.67			Valid	
	X_{26}	0.25	0.87			Valid	
	X_{27}	0.47	0.73			Valid	
Evaluating	X_{28}	0.67	0.57	0.91	0.53	Valid	Reliabel
	X_{29}	0.58	0.65			Valid	
	X_{30}	0.45	0.74			Valid	
	X_{31}	0.34	0.81			Valid	
	X_{32}	0.44	0.75			Valid	

The results of the path analysis indicate that all indicators in planning and evaluating activities are declared valid and reliable, but there is one indicator in monitoring activities that is invalid, so that this indicator is not suitable to measure the success of monitoring activities.

In activity planning, the indicators formulated describe the activities of learners to prepare their potential in learning through independent exploration and elaboration activities. This activity is an implementation of metacognitive strategies and constructivist learning. According to Du Toit (2013), metacognitive strategies include planning, setting and pursuing goals, evaluating a person's way of thinking and acting; identify difficulties, and elaborate. Meanwhile, according to Muijs & Reynolds (2008), in constructivist learning, learning is an active process and a search for meaning that requires big ideas and exploration. So the indicators developed in activity planning are used to control and evaluate student activities in implementing metacognitive strategies and constructivist learning.

Of the twelve indicators formulated, there is one indicator with a relatively low validity value, namely the efforts of students to compile material concepts and make corrections to erroneous writing. In this section, it seems that students find it difficult to determine the quality of the writing they write. This problem arises for reasons: (1) mathematical concepts and material are more often packaged in the form of symbols and use very standard language, so that all written sentences are sentences that are considered important by students, (2) learning resources are referenced must be in accordance with the initial level of understanding that students already have, so that the number of learning resources does not guarantee the ease of compiling writing, and (3) the learning resources found may present different symbols, causing confusion.

In the monitoring phase, the instrument is used to evaluate the success of students in monitoring their self-understanding through collaborative problem solving activities, so that the self-evaluation indicators developed are related to the ability to build collaborative approaches or strategies, and the ability to verify discussion results. These activities are also part of metacognitive teaching strategies and problem solving teaching. According to Kramarski *et al.* (2002), teaching with metacognitive strategies is recommended by conditioning students in small groups to formulate and answer a series of metacognitive questions. Meanwhile, according to Hurme (2010), mathematical problem solving which is packaged in small groups will make students work effectively using their mathematical knowledge. Students who are able to find alternative approaches or strategies on problem solving tasks, will reuse them as corrections (self regulation) if they do and get the task again (Gartmann and Freiberg, 2012), and problem solving abilities are created by environmental factors. (Feist & Feist, 2013).

In monitoring activities, there is one indicator that is declared not suitable to be applied to measure the success of students' monitoring ability, namely "involvement in making improvements to improve results". This indicator does not seem to adequately describe its relationship with monitoring activities carried out by students. This happens because activities to make improvements to improve the results are generally carried out by those who make many mistakes in solving problems. So this indicator is an indicator that has a negative correlation with the monitoring activities carried out by students, so it is not suitable to be used in measuring the monitoring ability of students. According to Mclellan (Lu and Lin, 2017), collaborative problem solving has the goal of not only developing problem-solving skills but also guiding the development of cooperation and communication skills of students. Whereas Johnston *et al.* (Yin & Abdullah, 2013) states that collaborative problem solving is an active learning method that can stimulate learning, because the activities carried out can improve communication skills and group work skills.

In evaluating activities, indicators are used to control and evaluate the success of students to confirm and reflect on the new knowledge they have obtained. This is part of the metacognitive learning strategy and constructivist learning. According to Ghasempour *et al.* (2013), the learning process should be able to provide opportunities for students to reflect consciously on metacognitive experiences. Meanwhile, according to Muijs & Reynolds (2008), reflection is an implementation of constructivist teaching. Reflection on learning progress can provide opportunities for students to think about their thinking and this has the potential to encourage the development of students' metacognitive abilities (McGregor, 2007). The results of the validity test on the evaluating indicators show that the indicators of looking for additional information online produce the lowest validity value. The low validity of this indicator indicates several things: (1) the sources of information used by students still rely on books or paper-based, (2) students are not used to using internet facilities in learning, or (3) students do not have adequate facilities related to learning on line. So the validity of this indicator is influenced by the availability of learning tools, and this is an external factor. Therefore, although this indicator has a low level of validity, it is still suitable for use as a measurement instrument.

By looking at the overall results of the validation test, validity test, and reliability test above, it can be stated that the self-evaluation instrument of the PME learning model is both used as a control tool and a means of measuring the effectiveness of student activities in the planning, monitoring, and evaluating phases - in accordance with the established stages. in the PME learning model. Apart from functioning as a control tool, this instrument can also be used to strengthen learning assessments carried out by teachers on the cognitive and psychomotor dimensions of students, as well as peer-to-peer assessments that are commonly used to measure the dimensions of students' attitudes. This instrument is expected to encourage the emergence of metacognitive *learning* strategies, constructivist learning, and collaborative problem solving learning, to overcome students' low metacognitive performance in mathematics learning (Amin at al., 2017). Azorin (1991) argues, self-evaluation instruments should emerge as a powerful assessment instrument and as a learning tool. In order for learning to be more innovative, students need to carry out self-evaluation activities to support metacognitive activities. According to Veenman *et al.* (2006), monitoring, evaluation, and closing activities such as reflection are forms of metcognitive activities.

IV. CONCLUSION AND RECOMMENDATION

Overall from the above description, it can be concluded that: (1) the results of the expert and user validation tests state that the self-evaluation instrument developed meets the criteria worthy of use with a few revisions; (2) the results of the validity test on the 32 indicators developed showed that one indicator of monitoring activities was declared invalid, namely involvement in making improvements to improve the results, and (3) the results of the reliability test on indicators in planning, monitoring, and evaluating activities obtained a $CR \geq 0.70$ and $VE \geq 0.50$, this shows that the self-evaluation instrument used is reliable. Paying attention to these three things, it shows that the self-evaluation instrument developed in this study is suitable to be used to control and measure the planning, monitoring and evaluating activities carried out by students, especially in the implementation of the PME learning model.

The researcher realizes that it is very possible to find research inaccuracies that appear in this measurement, because according to Mohajan (2017), a valid tool must be reliable, but a reliable tool may not be valid. Therefore it is recommended to conduct further research, namely to test the instrument on a broader scale and to identify errors in the measurement process.

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