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To cite this article: S Mas'ula *et al* 2019 *J. Phys.: Conf. Ser.* **1387** 012065

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Designing of Active-Iconic-Symbolic Problem Based Learning Model (PBM-ENIKSI) for elementary school

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Abstract. The aim of this study was to develop an active-iconic-symbolic problem-based learning model (PBM-ENIKSI) in elementary school students so that students have a strong foundation when entering higher behaviours. This type of research is village research which was developed by Plomp to have three stages, namely preliminary research, development phase or prototyping, and the assessment phase. This study produced a system model of PBM-ENIKSI consisting of 5 stages, namely 1) initial debriefing of problem solving, 2) finding solutions to problem solving through concrete objects, 3) representing problems in tables/pictures/ diagrams/graphs, 4) Resolving Problems using Mathematical symbols, and 5) evaluation Problem Solving Solutions. This model will produce models in the form of books, student books and teacher manuals as a support system that can assist users in their application.

1. Introduction

This study will develop an active-Iconic-Symbolic Problem Based Learning (PBM-ENIKSI) model for primary school students, because the learning process requires a knowledge construction process. Joyce & Calhoun [1] states that the learning process is not merely a process for receiving information, ideas and skills, but in the learning process also includes the reconstruction of new ideas or knowledge by the mind. The development and change of mathematics education, one of which is influenced by a shift in views on how students can learn to learn mathematics (Herman, [2]). Mathematics plays a big role in developing human thoughts, bringing strategic, systematic reasoning processes used in problem analysis and solving. It helps people to be able to anticipate, plan, decide, and properly solve each problem in daily life. Learning that is still dominated by teachers, abstract learning, makes it difficult for students to understand the material, and thereby influence the learning outcomes of students, and sees mathematics as a boring subject (Trianto [3], Wahyudin [4]; Ruseffendi [5]; Fauzan [6], Ali, Hukamdad, Akhter & Khan [7]); Suara [8] Of course, this is contrary to the requirements of the 21st century, which are critical thinking and problem solving thinking, creativity and innovation, communication, cooperation, and global awareness.

Furthermore, the Directorate of Training Program Profession in Widdiharto [9] also revealed that most teachers in teaching is still less attention to students' thinking skills. This is supported by the results of



the Okereke study [10]; Bassey, Joshua & Asim [11]. Burns [12] adds that teachers in classes routinely focus on procedural learning, not on conceptual understanding. In other words, the learning done is less meaningful, less attention to students' thinking abilities, learning methods that are less varied, and as a result lack of students' confidence level which results in low learning outcomes and problem solving abilities. In addition, student difficulties in solving mathematical problems are also caused by: (a) students cannot understand the whole or some parts of the problem due to the lack of imagination and experience needed to consider the problem; (b) students have difficulties in reading and comprehension, unable to understand what important information is in a problem and organize it accordingly. Thus they cannot invert to the text into mathematical symbols; (c) teachers focus on following examples given in textbooks rather than teaching the principles behind each problem; (d) teacher teach without concern with thinking process orders (Phonapichat (in Phonapichat [13])).

The low problem-solving ability of students in Indonesia is known from the results of a survey of the Trends of the International Mathematics and Science Study (TIMSS) and Program for International Student Assessment (PISA) (Puspendik Team [14]; Kompas [15]; United Nations Development Program Team [16] which proves lack the literacy skills compared with other countries. From the survey data showed that Indonesia ranks only the top 5 countries that followed the bottom of the test starting in 2003 until 2012. The TIMSS and PISA study core strengths lie in students' mathematical reasoning and the ability to apply them in everyday life. Based on these problems, the importance of instilling early math concepts in students is that students have a solid mathematical foundation when entering a higher level, as described by Stylianides [17].

The development of the PBM-ENIKSI model is one of the effective ways to improve the quality of mathematics learning in elementary schools. In implementing these PBM models, giving problems at the beginning of learning is the main characteristic. As stated by Delisle [18]; Barrett [19]; Duch, Groh, & Allen [20] that giving problems at the beginning of learning related to daily life, complex and unstructured will be able to motivate students to solve problems in the learning process. The problem will be solved by students according to the stage of cognitive development of elementary school students who are in the concrete operational stage. Wakiman [21] added that in this period also, students had begun to develop concepts by using concrete developments to investigate relationships and models of abstract ideas, language was a tool for creating concepts, students had begun to be able to think logically, and the concept of eternity was already well received.

2. Literature Review

2.1 Concept of Problem Based Learning (PBL)

PBL is a structured model that can help students to be able to build knowledge and problem solving skills and help students to master important knowledge (Delisle, [18]). PBL has several advantages as explained by Arends & Kilcher [22], namely (a) actively involving students, (b) utilizing students' curiosity, (c) improving high-level thinking skills, and (d) applying information obtained in future. PBL takes cognitive psychology as its theoretical support. Cognitive learning theory is a learning theory that is more concerned with the learning process than the learning outcomes themselves. For followers of this school, learning does not only involve the relationship between stimulus and response. But more closely than that, learning involves a very complex thought process (Gredler, [23]). Cognitive learning in Bruner's view is a tool of conception (instrumental conception). Cognitive growth or can also be called intellectual maturation is the increase in responses characterized by the essence contained in stimulation. This growth depends on internal conditions in the information storage system or psychological frame (Sudjana, [24]).

2.2 Bruner's Stage of Representation

Representation is expressions of mathematical ideas in the form of problems, statements, definitions, etc. that are used to show or communicate the results of their work in a certain way as a result of the interpretation of his mind. NCTM [25] explains that representation developed by students helps the

teacher to understand the way students interpret and his thoughts about mathematics Bruner (in Luitel, [26]) distinguishes three types of mental representation models, namely (a) active representation that is related to sensory representations of motors formed through actions or movements; (b) iconic representations, namely representations in the form of visual shadows, images, or diagrams that describe concrete activities; and (c) symbolic representations that are related to mathematical language and symbols. Every development of a higher representation is influenced by other representations. Mathematical representation is closely related to mathematical problem solving. Furthermore, Hwang, et al. [27] states that the process of successful problem solving depends on representation skills which include construction and using mathematical representations in words, graphs, tables, and equations, solving and manipulating symbols. This is confirmed based on the results of his research that good representation ability is the key to obtaining the right solution in problem solving.

2.3 The Concept of active-Iconic-Symbolic Problem-Based Learning (PBM-ENIKSI)

Active-Iconic-Symbolic Problem Based Learning (PBM-ENIKSI), is an integration of Bruner's representation into PBL models to develop students' problem solving abilities. Polya [28] states that there are four stages in problem solving, namely (a) understanding the problem, (b) devising a plan, (c) carrying out the plan, and (d) looking back. The PBM-ENIKSI model is a learning model that starts with giving problems to students, then students solve problems following the Bruner representation stage, which begins with the help of concrete objects to abstract problem solving. The PBM-ENIKSI model was developed to develop and develop students' mathematical problem solving abilities by providing freedom, opportunity, attention and guidance that enable students to obtain problem-solving solutions according to the type of representation through the process of experiencing themselves in learning, so that mathematics learning becomes more meaningful, enjoyable, and democratic.

The PBM-ENIKSI model is an effective model for improving the quality of mathematics learning in elementary schools. Based on its characteristics, elementary school students are at the stage of development of concrete operational thinking. At this stage, students still need help to understand the subject matter delivered through modeling new concrete objects which will later be able to present material in abstract (mathematical symbols). So that learning can be understood according to the level of cognitive development of students, the learning material needs to be presented according to the stages of cognitive development or knowledge of students so that knowledge can be internalized in the mind (cognitive structure) of students.

This PBM-ENIKSI model rests on the understanding of the flow of constructivism education, which is motivated by the theories of Piaget and Vygotsky. Trianto [3] states that the theory of cognitive development as a process of students actively builds knowledge and understanding reality, through experiences that have been experienced and interactions between students and their environment. In its application, the teacher is expected to be able to create a condition so that the assimilation process and accommodation can run effectively. In addition, teachers are also asked to pay attention to the diversity of abilities among students so that certain conditions are created by the teacher, so that the potential of each student can develop optimally.

3. Methodology

Development Active-Iconic-Symbolic Problem Based Learning (PBM-ENIKSI) for Elementary School uses a design development Plomp [29], which has three stages or phases, namely: 1) Preliminary Research; 2) Development or Prototyping Phase; and 3) Assessment Phase. In this study, researchers only discuss until the stage or Prototyping Development Phase, the prototype design stage. Here are the steps being taken to or Prototyping Development Phase.

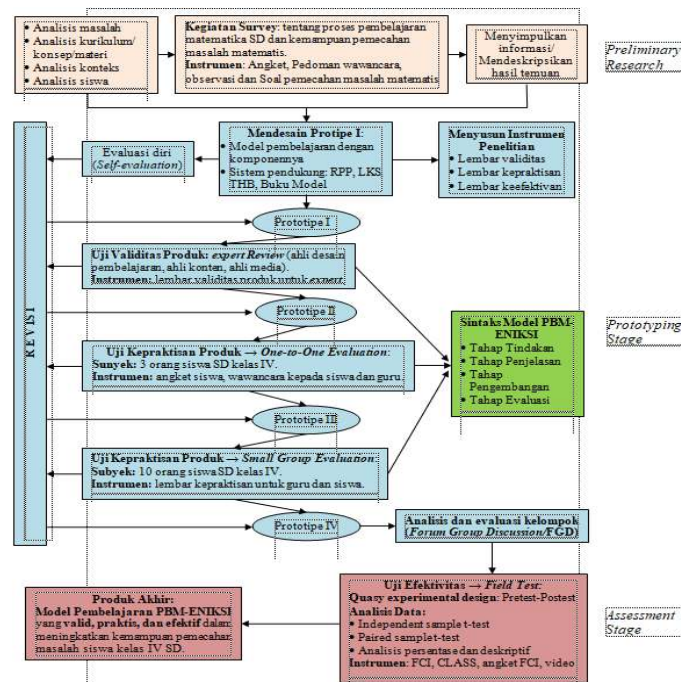


Figure 1. Procedure for Developing Active-Iconic-Symbolic Problem Based Learning Models (PBM-ENIKSI) ([Modifications from Plomp [29])

4. Results and Discussion

Based on research carried out at the preliminary stages of research and prototyping phase which is the first and second phases of design development Plomp [29], then the results are as follows:

4.1 Preliminary Research

This preliminary study was conducted with field survey activities. Pre-survey is done by conducting interviews with teachers and fourth grade students, as well as observing the mathematics learning process in the classroom. The data obtained is based on this pre-survey activity which then becomes the basis for developing the PBM-ENIKSI model. Based on the results of interviews conducted on fourth grade teachers in two elementary schools in the city of Padang, two of the three teachers knew that mathematics learning should begin with the provision of contextual problems and problem solving to be the focus of learning, but in its implementation it has not been fully implemented in learning. While other teachers begin learning by explaining learning material to students, then giving examples of questions that are abstract (using mathematical symbols). Next the teacher asks the students to work on the problem for the solution as exemplified before.

In addition, from the results of the survey, information was also obtained that in order to develop students' learning experiences in the learning process of mathematics, the teacher had used teaching aids or learning media to support the learning process. On the other hand, two of the three teachers also applied a cooperative model. Thus, from the results obtained information that students have had the experience of learning to use teaching aids and learning in groups. However, some difficulties experienced by students and teachers are still found, especially in KPK and FPB learning.

Based on the pre survey results, it can be concluded that in mathematics learning for fourth grade students elementary school is needed, namely: (a) Learning is focused on problem solving activities; (b) Mathematics learning for grade IV elementary school in semester 1 which includes FPB and KPK material tailored to the PBM-ENIKSI model; (c) Learning begins with giving a problem in the form of

a story; (d) Student-centered learning activities; and (e) Learning is adjusted to the level of cognitive development of students who are in the concrete operational stage.

4.2 Prototyping Stage

In this study, carried out the prototype stage to the stage of the initial product revision. From the results of the design was done until the prototyping phase (development phase Plomp), there are five aspects which are designed among other things, 1) modeling, 2) designing a social system, 3) designing principles of reaction, 4) design a support system, 5) designing impact instructional and accompanist. Based on the initial draft of which has been designed, there are several aspects that need to be fixed in accordance with the suggestion of several validators. Here are some suggestions 5 validators consisting of language experts, design experts, practitioners (elementary school teachers) and mathematics education experts.

Table 1. Suggestions to the Draft Preliminary Validator Active-Iconic-Symbolic Problem Based Learning (PBM-ENIKSI) for Elementary School

No	Name of Expert	Areas of Expertise	Suggestions for Improvement
1	Prof. Dr. I Made Arnawa, M. Si	Mathematics education	In student books: a. The problem presented is not clear, replace it with a mathematical problem. b. Adjust material with curriculum in elementary (K-13). c. Create work steps for students so students can work or study independently with the guidelines or steps given. d. Add enrichment and remedial material. e. The preparation of student books is in accordance with the guidelines for compiling the K-13 book. In the teacher's book: f. The preparation of the teacher's book please refer to book K-13
2	Elinisfa, M. Pd	Teachers of Elementary school	On RPP: In apperception activities, add ways to motivate students by singing.
3	Dr. Mardiah Harun, M. Pd	language (elementary school mathematics)	In student books: a. Use simple language so that it can be understood by fourth grade elementary students. b. Change problems with math problems. In the teacher's book: a. The syntax of the model is included in the core activities. b. List what activities students do are found in the student book on which page. On RPP: Teacher and student activities do not need to be separated.
4	Prof. Dr. Syahrul R, M. Pd	Language	In the teacher's book: a. The selection and use of letters (fonts) must be consistent. b. The word "concrete" should be "concrete". c. The word "Simboli" on the cover should be "symbolic". In the model book: a. Reach the latest try. b. For sources that are the main reference (such as Dienes and Piaget), they are updated by looking for references from the

			journal.
			In student books:
			a. The word "Simboli" on the cover should be "symbolic".
			b. The title of the problem does not need to be underlined.
5	Dr. Ramalis Hakim, M. Pd	Design	a. Overall the product developed is good. b. It is better to add a theoretical study of book design in Chapter II. c. Try printing the cover using photo paper.

Based on the results of the initial validation, then obtained some very useful overview for the repair of the product. From the results of these improvements, obtained 5 syntax supports this model, including: (a) Initial debriefing of problem solving, (b) Finding Solutions for Problem Solving Through Concrete Objects, (c) representing Problems in Tables/Pictures/ Graphics, (d) Resolving Problems Using Mathematical Symbols, and (e) Evaluating Problem Solving Solutions.

In order for the syntax of the PBM-ENIKSI model to be carried out to the fullest, several things need to be developed by the teacher in order to further strengthen the model, namely (a) Constructivists. The teacher's presence helps students construct and develop the initial mathematical problem solving abilities that students have; (b) The learning process is adjusted to the stages of cognitive development of elementary school students who are in the concrete operational stage (Ornstein & Hunkins [30], Slavin [31]). Therefore, the process of finding solutions to the problems presented is directed first using the help of concrete objects; (c) Giving freedom to make a representation of the problem at hand. This is intended to motivate students to develop students' mathematical problem solving abilities. The aim is so that students are active and directly involved in the learning process. As explained by Deporter, et al. [32] that providing direct experience will improve and make it easier for students to understand the content of learning; (d) inquiry. Students are encouraged and given space, as well as opportunities to take initiative in developing problem solving and decision-making skills so students can develop their thinking skills; (e) cooperation. Students are guided and directed to be able to cooperate well, respect each other, and be democratic. And (f) reinforcement. Giving positive reinforcement will make learning effective. In addition, positive reinforcement can reduce disturbing behavior and can increase student motivation (Hall et al [33]; Hayati [34]). According to the theory Skinner (in Ruseffendi [5]), reward and reinforcement has a very important role in learning. Therefore, the importance of mathematics in learning mathematics is a subject for students, but a lesson fun.

Based on an explanation of the syntax and some things need to be developed by the teacher, it will further strengthen the application of the PBM-ENIKSI model to elementary school students. Because the syntax of the PBM-ENIKSI model is designed based on the characteristics of elementary school students, so this model is very suitable to be applied to elementary school students.

5. Conclusion

Based on the results of the initial validation of the model has been designed, then the resulting 5 stages Active Iconic Symbolic Problem Based Learning (PBM-ENIKSI) for elementary school, namely: (a) Initial debriefing of problem solving, (b) Finding Solutions for Problem Solving Through Concrete Objects, (c) Representing Problems in Tables/ Pictures/Graphics, (d) Resolving Problems Using Mathematical Symbols, and (e) Evaluating Problem Solving Solutions. Furthermore, the PBM-ENIKSI Model also produces six important things that teachers must develop, namely: (1) constructivism, (2) the use of concrete objects, (3) freedom of representation, (4) inquiry, (5) cooperation, and (6) reinforcement.

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Acknowledgments

Completion of studies cannot be separated from the support of various parties. Therefore, the author would like to thank: The Director of education fund management institution (LPDP) of the Ministry of Finance of the Republic of Indonesia has provided dissertation fund assistance to researchers. Prof. Dr. Ahmad Fauzan, M. Pd, M. Sc as Promoter 1. Prof. Dr. Ellizar, M. Pd as Promoter 2. Dr. Darmansyah, M. as Promoter 3. All parties that cannot be mentioned one by one.