The Validity of Enactive Iconic Symbolic Problem Based Learning Model (PBM-ENIKSI) for Elementary School

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Abstract
The purpose of this research was to produce a practical, valid, and effective Enactive Iconic Symbolic Problem Based Learning model (PBM-ENIKSI) for elementary school fourth grade students. This research produces several products as model books, teacher books, and student books. The research design developed by Plomp consists of three stages, namely preliminary research, development or prototyping phase, and assessment phase. The preliminary research stages are analyzed by needs analysis, student analysis, curriculum analysis, and concept analysis. The development or prototyping phase was conducted by doing self evaluation, expert validation, one-to-one evaluation, and small group evaluation. As in the assessement phase, a large group field test was conducted through an Enactive Iconic Symbolic Problem Based Learning model (PBM-ENIKSI) for elementary school fourth grade students. Based on the results of product validity by expert validation, the data obtained results in a very valid product.

Keywords: Enactive-Iconic-Symbolic Problem Based Learning model, Plomp, validity.

Introduction

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, 2007). Mathematics plays a big role in developing human thoughts, bringing strategic and systematic reasoning processes used in problem analysis and solving. It helps people to be able to anticipate, plan, decide, and properly solve daily life problem. Learning that is still dominated by teachers and abstract learning makes it difficult for students to understand the material, and thereby influence the learning outcomes of students. Consequently, students see mathematics as a boring subject (Trianto (2007), Wahyudin (2008); Ruseffendi (1980); Fauzan (2002), Ali, Hukamdad, Akhter & Khan (2010)); Suara (2016).This is contrary to the 21st century trait requirements, which demands critical thinking and problem solving, creativity and innovation, communication, cooperation, and global awareness (Marjohan, 2013).

Widodo (2010) revealed that 11.35% of mathematics teachers in Indonesia are not competence enough. This is supported by the results of the Okereke study (2006),and Bassey, Joshua & Asim (2007). Burns (2004) adds that teachers in classes routinely focus on procedural learning, not on conceptual understanding. In other words, the learning done is less meaningful, less attentive to students' thinking abilities, less varied learning methods, resulting in lack of students' confidence level and low learning outcomes and problem solving abilities. In addition, students' difficulties in solving mathematical problems are also caused by: (a) students' in capability to understand the whole or some parts of the problem due to the lack of imagination and experience; (b) students' difficulties in reading and comprehending the material thus disabling them to understand important information in a problem and organize it accordingly. Thus, they cannot invert the text into mathematical symbols; (c) teachers' focus on following examples given in textbooks rather than teaching the principles behind each problem; (d) teachers' ignorance to critical thinking process orders (Petchuay, 1998; Phonapichat, 2013).

The Indonesian students' low problem-solving ability is gained 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 (2012); Kompas (2013); United Nations Development Program Team (2015) which proves lack the literacy skills compared with other countries. The survey's data show that Indonesia ranks the top 5 countries from the bottom of the test 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, as described by Stylianides (2007) students need to have a solid mathematical foundation when entering a higher level.

Problem Based Learning (PBL) is a structured model that can help students to be able to build knowledge and problem-solving skills to master important knowledge (Delisle, 1997). As explained by Arends & Kilcher (2010) PBL has several advantages: (a) actively involving students, (b) utilizing students' curiosity, (c) increasing high-level thinking skills, and (d) applying information obtained in the future. PBL takes cognitive psychology as its theoretical support. Cognitive learning theory is a learning theory that concerns more 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, 2011). 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, 1991).

The representation is an expression 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 (Kartini, 2009). The representation developed by students helps the teacher to understand the way students interpret and think about mathematics (NCTM, 2000). Bruner (Luitel, 2001) distinguishes three types of mental representation models, namely (a) active representation which is related to sensory representations of motors formed through action or movement; (b) iconic representation, namely representation in the form of visual shadows, drawings, or diagrams that describe concrete activities; and (c) symbolic representation that is related to mathematical language and symbols. These three types of representations are related to one's mental development. Every higher development of representation is influenced by other representations. Mathematical representation is closely related to mathematical problem solving. Furthermore, Hwang, et. al (2007) states that the process of problem-solving success 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.

Enactive-Iconic-Symbolic Problem-Based Learning (PBM-ENIKSI) is an integration of Bruner's representation into PBL models to develop students' problem-solving abilities. Polya (1973) states that there are four stages of problem solving, namely (a) understanding the problem, (b) devising a plan, (c) carrying out the plan, and (d) looking back. The Enactive-Iconic-Symbolic Problem-Based Learning 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 Enactive-Iconic-Symbolic Problem-Based Learning model was developed to 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.

Enactive-Iconic-Symbolic Problem Based Learning Model is one of the effective models to improve the quality of mathematics learning in elementary schools. Based on its characteristics, elementary 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). Hence, 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 thus knowledge can be internalized in the mind (cognitive structure) of students.

This model rests on the understanding of the flow of constructivism education, which is motivated by the theories of Piaget and Vygotsky. Trianto (2007) states the theory of cognitive development as a process of students actively building knowledge and understanding reality through experiences 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 with certain conditions created by the teacher, the potential of each student can develop optimally.

Methods

This type of research is development research, using the development design of Plomp & Nieveen (2010) which has three stages, namely: preliminary research, prototyping stage, and assessment stage. In this study, the researchers only discussed the stage of doing formative evaluation, that is doing validity tests to some experts consisting of language experts, design experts, practitioners (elementary school teachers) and mathematics education experts.

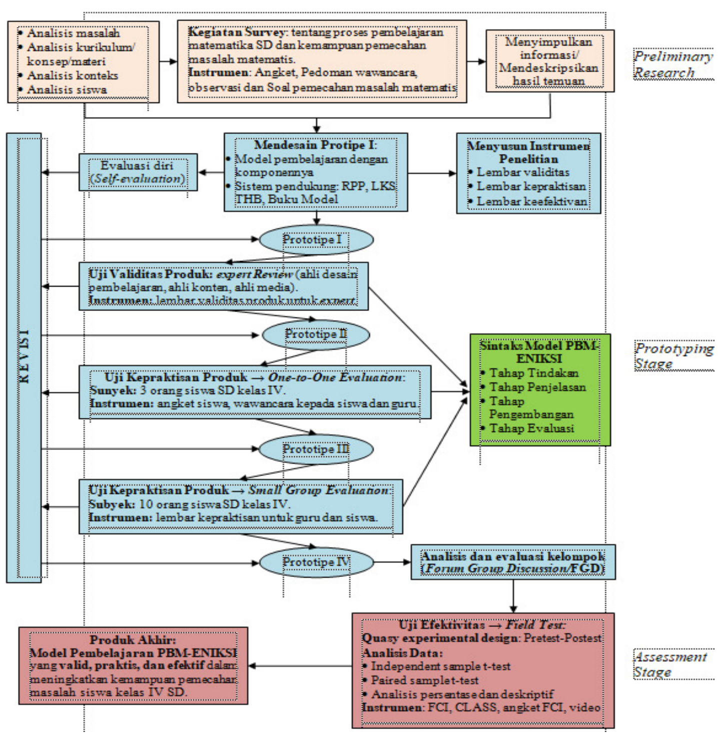

Figure 1. Procedures for Developing Enactive-Iconic-Symbolic Problem Based Learning Model (Plomp & Nieveen, 2010)

Results and Discussion

The results showed that the resulting product is at a very valid criteria. Here are the results of the validation by 5 validators which is composed of experts in the fields of mathematics, Indonesian, and design.

Table 1. Results of the Validation of Components of the Enactive Iconic Symbolic Problem Based Learning Model for Elementary School

No	Early Draft	Research	
		Quantitative	Qualitative
1	Syntax	4.5	Very Valid
2	Social System	4.3	Very Valid
3	The reaction was	4.1	Very Valid
4	Impact Instructional and Accompaniment	4.3	Very Valid

Table 2. Results of the Validation of Teacher's Book of the Enactive Iconic Symbolic Problem Based Learning Model for Elementary School

No	Early Draft	Research	
		Quantitative	Qualitative
1	General instructions	3.9	Valid
2	Special instructions	4.5	Very Valid
3	Book size	5	Very Valid
4	Design of book cover	4.7	Very Valid
5	Design of book content	4.9	Very Valid
6	Evaluation component	4	Very Valid
7	Presentation component	4.3	Very Valid
8	Linguistic component	4.2	Very Valid
9	Complete presentation component	4.7	Very Valid

Table 3. Results of the Validation of Student's Book of the Enactive Iconic Symbolic Problem Based Learning Model for Elementary School

No	Early Draft	Research	
		Quantitative	Qualitative
1	Eligibility	4.6	Very Valid
2	Evaluation PBM-ENIKSI	4.5	Very Valid
3	Book size	5	Very Valid
4	Design of book cover	5	Very Valid
5	Design of book content	5	Very Valid
6	Presentation	4.9	Very Valid
7	Linguistic	4.5	Very Valid

Table 4. Categorization Criteria validity of the Enactive Iconic Symbolic Problem Based Learning Model for Elementary School

Interval Score	Validity Category
$4 \leq VR \leq 5$	Very Valid
$3 \leq VR < 4$	Valid
$2 \leq VR < 3$	Less Valid
$1 \leq VR < 2$	Invalid

(source: Khabibah, 2006)

Based on the results of the research, it is seen that the resulting product is at very valid criteria. Thus, the resulting product has good quality. This is according to what Nieveen describes, a number of common criteria that must be met in order to produce good quality products, namely validity, practicality and effectiveness (Plomp & Nieveen (2013: 28). According to Nieveen, aspects of validity can be seen from: 1) whether the developed curriculum or learning model is based on a strong theoretical rationale, and (2) whether the various components of the learning tool are consistently linked to one to another.

The Enactive Iconic-Symbolic Problem Based Learning Model is seen from its constituent components, namely syntax, social system, reaction principles, support system, instructional impact, and the accompanying criteria are very valid. This shows that the model developed illustrates supporting theories that are relevant and in accordance with the characteristics of elementary school students. In addition, the components developed in the model are also interrelated and are able to develop mathematical problem-solving abilities as expected.

In the teacher's book, it is also seen that general instructions, special instructions, book size, design of book cover, design of book content, evaluation component, presentation component, linguistic component and complete presentation component are on very valid criteria. This means that the teacher's book has been arranged in line with the stages of development of elementary school students and can develop mathematical problem-solving abilities. In the student book, it also appears that eligibility, evaluation PBM-ENIKSI, book size, design of book cover, design of book content, presentation, and linguistic are on very valid criteria. This means that the components described in the student book have been able to develop the mathematical problem-solving abilities expected in the model, and student books are also in line with the stages of development of elementary school students.

Thus, it can be concluded, that the products produced can be used for elementary school students. Based on the characteristics of elementary school students, the PBM-ENIKSI model is suitable to be developed because through this model students can develop mathematical problem-solving abilities. The learning process becomes more meaningful because students can construct understanding by conducting independent investigations. The instructions given can stimulate students to conduct further information searches (Kohlhaas, 2011). In addition, several studies also explain that problem-based learning can help students improve mathematical problem-solving skills (Ibrahim, 2011; Tasdikin, 2012). Through model books, teacher manuals and student books, which are models of support systems, it is hoped that it will be easier for teachers and students to apply the Enactive Iconic Symbolic Problem-Based Learning Model for elementary school students so that mathematics learning becomes meaningful. Learning can develop positive relationships between students and the environment. Additionally, students could see themselves becoming better, confident, responsible for their education, more creative in solving problems. Therefore, students can develop all potential as intellectual, spiritual, emotional, psychomotor, and aesthetic potential.

Conclusions

Based on the results of the research and discussion it can be concluded that the development of the Enactive Iconic Symbolic Problem Based Learning model is on a very valid criterion. Thus, the PBM-ENIKSI model in elementary schools can be used in accordance with the syntax and components that have been designed in the Enactive Iconic Symbolic Problem Based Learning model.

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References

Ali, R., Hukamdad, Akter, A. & Khan, A. (2010). Effect of Using Problem Solving Method in Teaching Mathematics on The Achievement of Mathematics Students. *Social Science*, 6 (2); 67-72. Tersedia: http://ccsenet.org/journal/index.php/ass/article/viewfile/5040/4181. [11 Januari 2017]

Arends, R.I. & Kilcher, A. (2010). *Teaching for Student Learning: Becoming an Accomplished Teacher*. New York: Routledge.

Bassey, S. W., Joshua, M. T. & Asim, A. E. (2007). *Gender differences and mathematics achievement of rural senior secondary students in Cross River State, Nigeria*. Tersedia: http://web.gnowledge.org/episteme3/pro_pdfs/09-bassvjoshua-asim.pdf. [28 Februari 2017].

Burns, M. (2004). "Problem-Solving Lessons: Grades 1-6". Tersedia: http://books.google.com.ph/books. [27 Juli 2017].

Delisle, R. (1997). *How to Use Problem-Based Learning in The Classroom*. Alexandria, VA: ASCD.

Fauzan. (2002). *Applying Realistic Mathematics Education in Teaching Geometry in Indonesian Primary School*. Doctoral Dissertation, University of Twente, Enschele, The Netherland.

Gredler, M. E. (2011). Learning and instruction: Teori dan aplikasi (edisi keenam). Jakarta: Kencana Prenada Media Group.

Herman, T. (2007). Pembelajaran Berbasis Masalah Untuk Meningkatkan Kemampuan Berpikir Matematis Tingkat Tinggi Siswa Sekolah Menengah Pertama. Tersedia: http://file.upi.edu/Direktori/JURNAL/EDUCATIONIST/Vol._I_No._1Januari_2007/6._Tatang_Herman.pdf. [23 Januari 2018].

Hwang, W.-Y., *et al*. (2007). "Multiple Representation Skills and Creativity Effects on Mathematical Problem Solving using a Multimedia Whiteboard System". *Educational Technology & Society*, 10 (2), 191-212. [Online]. Tersedia: www.ifets.info/journals/10_2/17.pdf [20 Juli 2017].

Ibrahim. (2011). *Peningkatan Kemampuan Komunikasi, Penalaran, dan Pemecahan Masalah Matematis serta Kecerdasan Emosional melalui Pembelajaran Berbasis-Masalah pada Siswa Sekolah Menengah Atas.* Disertasi doktor, tidak diterbitkan, Universitas Pendidikan Indonesia. Tersedia: http://repository.upi.edu/disertasiview.php?no_disertasi=225. [23 Maret 2018].

Khabibah, S. (2006). Pengembangan Model Pembelajaran Matematika dengan Soal Terbuka untuk Meningkatkan Kreativitas Siswa Sekolah Dasar. *Disertasi. Universitas Negeri Surabaya.*

Kohlhaas, B. (2011). *A Study of Problem Based Learning in The Middle Classroom.* Tersedia: http://scimath.unl.edu/MIM/files/research/KohlhaasAR_Final_LA.pdf. [19 Februari 2018].

Kompas. 2013. 5 Desember. *Posisi Indonesia Nyaris Jadi Juru Kunci: Kemampuan Matematika dan Sains di Urutan Ke-64 dari 65 Negara.* Tersedia: http://www.kopertis12.or.id/2013/12/05/skor-pisa-posisi-indonesia-nyaris-jadi-juru-kunci.html. [5 Januari 2017].

Okereke, S. C. (2006). Effect of Prior Knowledge of Implementing Mathematical Task/Concepts to Career Types and Gender on Students' Achievement, Interest and Retention. In U. Nzewi (Ed.), *Proceedings of the 47th Annual Conference of the Science Teachers' Association of Nigeria (STAN)*, pp 253-259.

Phonapichat, Prathana, et. Al. (2015). An Analysis of Elementary School Students' difficulties in mathematical problem solving. *Procedia-Social and Behavioral Sciences*. Pp 3169-3174.

Petchuay, Uthai. (1998). *Teaching Mathematical problem by four questions*. Ministry of Education. Tersedia: http://lib.edu.chula.ac.th/cuappl/libedu2007/content.asp?mode=searchjournal [1 Maret 2019].

Plomp, Tjeerd dan Nieveen, Nienke. (2010). "An introduction to educational design research". *Proceedings of the Seminar Conducted at the East China Normal University, Shanghai (PR China)*.

Polya, George. (1973). *How to solve it.* Princeton, NJ: Princeton University press.

Puspendik. (2012). *Kemampuan Matematika Siswa SMP Indonesia Menurut Benchmark International TIMSS 2011.* Jakarta: Pusat Penilaian Pendidikan Badan Penelitian dan Pengembangan Kementerian Pendidikan dan Kebudayaan.

Ruseffendi, E. T. (1980). *Pengajaran Matematika Modern dan Masa Kini untuk Guru dan SPG*. Bandung: Tarsito.

Stylianides, Andreas J. (2007). *The Notion of Proof in the Context of Elementary School Mathematics.* Educational Studies in Mathematics (2007) 65: 1–20 (DOI: 10.1007/s10649-006-9038-0).

Suara. 2016. 5 Oktober. *Alasan Mengapa Matematika Sulit Terungkap dalam Survei yang Dilakukan pada 2010.* Tersedia: http://www.suara.com/tekno/2016/10/05/110207/profesor-ini-ungkap-mengapa-matematika-dianggap-sulit. [28 Maret 2017].

Sudjana, Nana. (1991). *Dasar-dasar Proses Belajar Mengajar*. Bandung: Sinar Baru.

Tasdikin. (2012). *Pembelajaran Berbasis Masalah untuk Meningkatkan Kemampuan Komunikasi dan Pemecahan Masalah Matematis Siswa SMP*. Tesis Magistr, tidak diterbitkan, Universitas Pendidikan Indonesia. Tersedia: http://repository.upi.edu/tesisview. [23 Maret 2018].

Trianto. (2007). Model-model Pembelajaran Inovatif berorientasi kontruktivistik. Prestasi Pustaka: Jakarta.

United Nations Development Programme Team. 2015. *Human Development Report 2015.* USA: Communications Development Incorporated.

Wahyudin. (2008). *Pembelajaran dan Model-model Pembelajaran*. Bandung: UPI.