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LITERATURE STUDY ON THE THEORY OF GROWTH MATHEMATICAL UNDERSTANDING PIRIE AND KIEREN

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Abstract. This study aims to examine the literature on the theory of growth mathematical understanding Pirie & Kieren. This study explores international articles and national articles as part of the literature on dissertation preparation through download results. The type of data used is secondary data from articles on the theory of growth mathematical understanding of the school students and university students' in solving mathematics problems, especially on the level of mathematical understanding Pirie & Kieren. The data collection method used were reading, identifying, analyzing, categorizing, classifying, and describing. The results exposed that the theory of growth mathematical understanding Pirie & Kieren can be used to see the development of students' understanding in mathematics learning and to observe students' mathematical activities, especially in solving mathematics problems by referring to Pirie & Kieren's mathematical understanding indicators, namely primitive knowing, image making, mage having, property noticing, formalizing, observing, structuring, and inventising.

1. Introduction

Mathematical understanding is an important aspect in mathematical learning (NCTM, 2000). Pirie & Kieren (1994) state that understanding mathematics is a growth process which is complete, dynamic, layered but not linear, and never ends. The theory by Pirie & Kieren (1994) propose eight levels of understanding, namely: primitive knowing, image making, image having, property noticing, formalizing, observing, structuring, and inventising. The theory describes that "understanding" does not always grow linearly and continuously. A person often returns to the inner level of understanding to go forward to the outer level of understanding.

The researcher consider that theory of understanding Pirie & Kieren is appropriate for the teachers to use in facilitating students' learning in the classroom, besides the theory can also be used to identify the types of understanding which possessed by students. In the learning process, it allows the students to re-use existing understandings related to the problems. If necessary students will build new understandings to solve these problems. Therefore, this implies that when a student solves a mathematics problem, then he cannot solve the problem, he will return to the inner level of understanding. In Pirie & Kieren (1994) theory of understanding, this is called the folding back.

2. Experimental Method

The type of this study is literature study which examining **international articles and national articles**. This study is intended to gain the strength of scientific studies on the theory of growth mathematical understanding Pirie & Kieren. The data used were secondary data from articles about theory of growth mathematical understanding by Pirie & Kieren of school students and university students in solving math problems. The data collection method used was reading international articles and national articles. Furthermore, it was also carried out an identification of the theory growth of mathematical understanding Pirie & Kieren. The valid data was obtained by triangulating the original source of the article on the first author. On the final step, the researcher described the results of the literature review and conclude the study.

3. Result and Discussion

The theory of growth mathematical understanding was published in 1989 by Pirie & Kieren, so the theory is called "The theory of growth mathematical understanding Pirie & Kieren". This theory of understanding is different from other theories of mathematical understanding. Pirie & Kieren (1994) state "it is a theory of the growth of mathematical understanding as a whole, dynamic, levelled but non-linear, transcendently recursive process".

Mathematical understanding is a multi-layered but not linear growth process, there are levels in understanding. Nevertheless, in the process to reach a certain level of understanding, it is possible for a person to return to the previous level of understanding. Mathematical understanding is a growth process that never ends or a recursive event, which is a repetition of the process to gain an understanding. Repetition occurs when a new understanding is needed, it takes prior knowledge as the main asset. In addition, Pirie & Kieren (1994) also state *"understanding as occurring in action and not as a product resulting from such actions"*.

Pirie & Kieren (1994), Pirie & Martin (2000), Meel (2003), Martin, LaCroix, & Fownes (2005), Manu (2005), Thom & Pirie (2006), Martin (2008), Slaten (2015) , Susiswo (2014), and Sagala (2016) state that theory of growth mathematical understanding Pirie & Kieren has eight levels to describe the growth in person's understanding of a certain concept. The eight levels of understanding are embedded based on the cognitive changes which occur during the mathematics learning process. These processes are dynamic, recursive, and non-linear. The Pirie & Kieren (1994) level of understanding can be seen in Figure 3.1.

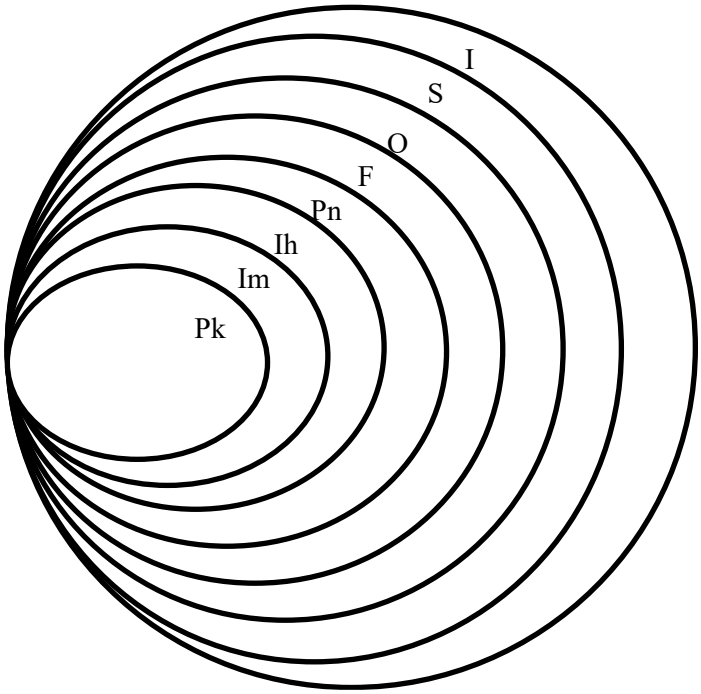

Figure 3.1. level of mathematical understanding Pirie & Kieren

Figure 3. 1 shows that level of mathematical understanding Pirie & Kieren, they are:

Based on the results of study on the several articles, the researcher concluded the indicators of mathematical understanding by Pirie & Kieren as follows:

Table 1. Pirie & Kieren mathematical understanding indicator

Level	Indicator
Primitive knowing (Pk)	Students make initial efforts to understand a new concept.
Image making (Im)	Students draw a concept based on the previous knowledge.
	Students develop certain images based on the previous knowledge.
Image having (Ih)	Students have images of a concept without working on examples.
Property noticing (Pn)	Students connect aspects of a topic to form traits which appropriate to the topic.
Formalizing (F)	Students make an abstraction of a mathematical concept based on the appeared traits.
Observing (O)	Students associate mathematical concepts that have been understood with new knowledge structures.
Structuring (S)	Students associate the relationship between a concept with the other concepts
	Students connect one concept to another based on logical arguments
Inventising (I)	Students create new questions that can grow into a new concept.
	Students create new concepts based on previous knowledge.

4. Coclusion

The theory of growth mathematical understanding can be used to see the development of students' understanding in mathematics learning and to observe the students' mathematical activities, especially in solving mathematics problems by referring to the mathematical understanding indicators Pirie & Kieren, namely *primitive knowing, image making, mage having, property noticing, formalizing, observing, structuring, and inventising.*

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