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Cognitive Stage Relation with Creative Thinking Ability and Mathematical Learning Interests

E E Rohaeti*, B G Ramadan and N Fitriani
Pendidikan Matematika, Institut Keguruan dan Ilmu Pendidikan Siliwangi, Jl. Terusan Jenderal Sudirman, Cimahi 40526, Indonesia

*Email: e2rht@ikipsiliwangi.ac.id

Abstract. This study aims to analyze the links between students' cognitive stages and creative thinking skills and mathematical learning interests. This study involved 36 11th grade students, test of logical thinking (TOLT), a description of the creative thinking ability (CTA), learning interest scale (LI). Based on TOLT, the study found the cognitive stage distribution of students as follows: 30% of students were in the formal stage, 25% were transitional stages, and 45% were concrete stages. In addition, the researchers found, overall in CTA and LI students achieve quality at a fairly good level. Judging from the cognitive stage of students, the quality of CTA and LI students in the formal and transition stages is classified as a fairly good level, and concrete students achieve the quality of CTA and LI at moderate levels. In addition to completing the CTA tasks, concrete students experience more difficulties while the students in the transition stage and the formal stage experience a little difficulty. Another finding is that there is no association between CTA and LI. Overall, the findings relate to the cognitive stage, the quality of the CTA and LI students based on their cognitive stages according to the child's Cognitive Development Theory.

1. Introduction

To determine the cognitive stage of students, our argument is related to the leading theory of Piaget's mental development theory, there are 4 stages of cognitive development in children, namely: (1) Sensory motor stage (sensory-motor stage), namely from birth to around 2 years old; (2) Pre operational stage, which is from around 2 years to around 7 years; (3) Concrete operational stage, which is from the age of around 7 years to around 11-12 years; and (4) Stage of formal operational stage, which is from the age of around 11 years to adulthood by Alhaddad [1].

Every stage of mental development has its own characteristics or characteristics that different children emerge. One characteristic that is raised at the concrete operation stage is that at this stage the child has begun to understand the concept of eternity. As stated by Ruseffendi [2], in the concrete operation stage children begin to understand the concept of conservation of numbers (6-7 years), the concept of conservation of matter or substance (7-8 years), the concept of longevity (7-8 years), the concept of immutability (8 - 9 years), the concept of conservation is heavy (9-10 years), even at the end of this stage, children can understand the concept of conservation of content (14-15 years). Ofcourse, it is intended for foreign children where Jean Piaget conducts research, namely in Switzerland.

Some experts realize that carrying out careful observations and in-depth interviews for a number of students of all ages at the same time will take a very long time. Therefore, Capie & Tobin [3] designed a written test to exchange Piaget's techniques. This test is called Test of Logical Thinking (TOLT) and consists of ten items that involve proportional reasoning, variable reasoning control, probabilistic reasoning, and combination reasons. Furthermore, Tobin & Capie [4] conducted a cross-cultural study related to the subject of non-Piaget culture from various classes ranging from the eighth grade to the students. The study found that there were many students with more than 15 years of age who had not yet reached the formal stage. In addition, cross-cultural studies have found that higher student scores have more formal students and fewer concrete students.

One component of the vision of mathematics, the purpose of national education, and the purpose of learning mathematics in schools include the ability to think creatively. The vision in question is to develop mathematical abilities: mastery of mathematical concepts and their application, and provide opportunities for the development of logical, systematic, critical and meticulous reasoning skills that are indispensable in facing an ever-changing future. Likewise, National Education [5], among others, aims to develop the potential of students to become knowledgeable, capable, critical, creative, and innovative human beings. As for the affective aspects of the mathematical vision, the goals of national education, and mathematics learning goals according to the Ministry of Education and Culture [6] are: healthy, independent, and confident; tolerant, socially sensitive, democratic, and responsible, respecting the usefulness of mathematics, curiosity, attention, and interest in learning mathematics, as well as tenacious and confident attitude.

Regarding the term creative thinking, some experts define it in various ways. Rhodes [6] defines creativity by analyzing its four dimensions known as "the Four P's of Creativity, or "four P's of creativity", namely Person, Product, Process, and Press. In the sense that creativity is a process that contains thinking skills which includes: fluency, flexibility, originality, and collaboration.

Coleman and Hammen [7] claim that creative thinking is a way of thinking that produces new concepts, inventions, or art. Sukmadinata [8] suggested the same thing argued that creative thinking is a mental activity including originality, sharp insight, and producing processes. Some steps in creative thinking are: asking questions, considering information in a new form of seeing and being open minded, looking for relationships between various things, seeing free relationships between one and the other, applying their thoughts to produce new and different things, and considering intuition.

The ability to think creatively is indispensable in facing increasingly complex problems in the future. Pucio and Murdock [3] argue, The use of the term creative thinking and creativity is often exchanged. Creativity is an umbrella construct as a creative product of creative individuals, contains stages of the creative thinking process, and a conducive environment for creative thinking to take place that contains aspects of cognitive, affective, and metacognitive skill [9].

Previously, it was explained that the lack of ability in the cognitive aspects of mathematical creative thinking was allegedly due to a lack of motivation to learn or it could be called a lack of affective aspects, namely interest in learning. Therefore, cognitive aspects, namely the ability to think creatively mathematically are important, and the affective aspects, especially interest in learning, are also important. Besides being explained previously, Purnama [10] emphasized that interest is very influential with the achievements that students will get. With a high interest in learning, the process of teaching and learning activities will be more enjoyable so students do not feel burdened. Students who have an interest in teaching and learning activities will try harder than students who have less interest. High interest that students have towards a subject, allows students to give high attention to those subjects so as to enable them to have high achievements. Therefore, to achieve high achievement, in addition to intelligence, student interest is also needed, because without interest the teaching and learning process runs less effectively.

Regarding Polya's learning, Glasersfeld, and Nickson [11] suggest that in mathematics learning the teacher's task is to help students develop mathematical concepts with their own abilities through an internalization process so as to form a meaningful new concept. Polya's opinion, Glaserfeld and Nickson as above, basically depicts learning that has constructive views and has characteristics including: (1) students are actively involved in learning, (2) new information is related to the knowledge they already have so as to form meaningful and more understanding complex; (3) learning emphasizes investigation and discovery [3].

The problems in mathematics learning that have been described previously must be addressed immediately, one of which, is to be creative and innovative teachers who can make mathematics learning fun, more interesting, not boring and liked by students [12]. In addition, in the learning activities the teacher is only a motivator and facilitator, while learning must be student-centered so that the classroom atmosphere comes alive.

The way to overcome students' displeasure in increasing learning interest in mathematics learning, as one of the important factors in learning, is the selection of teaching approaches that can stimulate, direct, shape active learning students and students can develop and improve mathematical creative thinking skills, and one of them by creating learning atmosphere that is in accordance with the conditions of the school environment. A pleasant learning atmosphere is expected to be able to spur students' enthusiasm, so that eventually the mathematical abilities that students get will also be better.

2. Method

This study is an experiment with only the control and posttest group design and aims to analyze the relationship between the cognitive stages of students in creative thinking skills and students' mathematical learning interests. The subjects of this study sample were 36 11^{th}-grade students from one high school purposively determined. The instruments of this study were: the Indonesian version of the TOLT test Tobin & Capie [4], the essay test of creative thinking ability and the mathematics learning interest scale prepared specifically for this study. TOLT consists of ten items and is measured proportionally, control variables, probalistic and combinatorial reasoning. The test of mathematical creative thinking skills consists of 5 items. The data analysis of this study includes: calculation of scoring items for learning interest scales, percentage calculations, hypothesis testing of average differences and the existence of a relationship between two variables, and rational analysis for certain relevant data.

The following are presented TOLT sample items, test sample items Creative Thinking Ability and sample items of the Mathematical Learning Interest scale.

a) Sample item of TOLT : The Fish

Are the fat fish more likely to have stripes than thin fish?

a. Yes
b. No

Reasons:

1. Some fat fish have broad striped and some have narrow stripes.
2. $\frac{3}{7}$ of the fat fish have broad stripes.
3. $\frac{12}{28}$ are broad striped and $\frac{12}{28}$ are narrow striped
4. $\frac{3}{7}$ of the fat fish have broad striped and $\frac{9}{21}$ of the thin fish have broad striped.
5. Some fish (see Figure 1) with broad stripeds are thin and some are fat

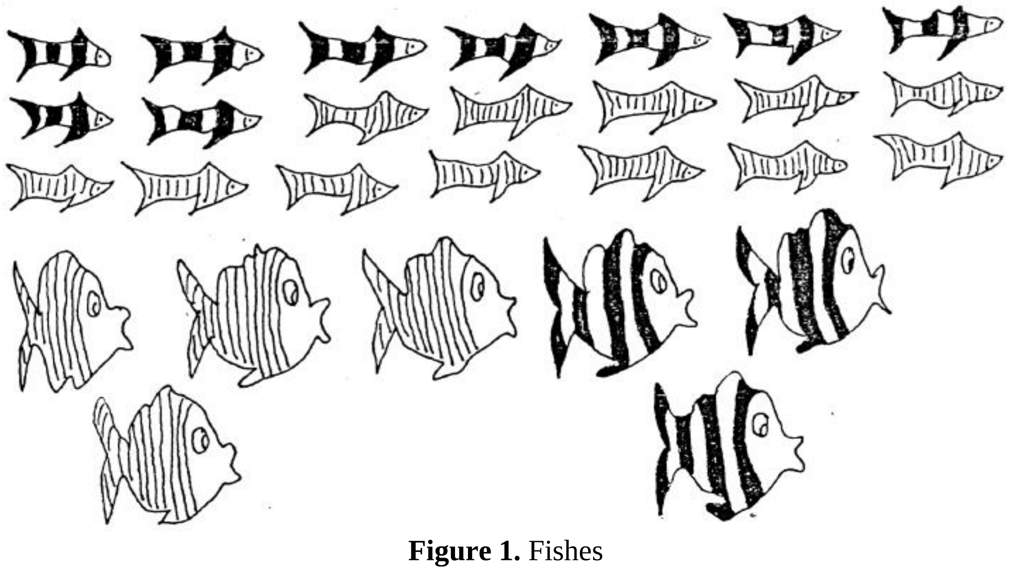

Figure 1. Fishes

b) Sample test item Creative Thinking Ability
Winda bought 240 bottles of cow's milk for sale again. He rented two types of containers to carry the milk. Large containers have a capacity of 6 bottles and small containers have a capacity of 4 bottles. The rent for each container in a row is Rp. 6,000.00 and Rp. 5,000.00 one way. He must rent a container of at least 48 containers.
a. How many large and small containers are rented so that the winda costs the least?
b. Draw the information in an equation and a table so it's easy to read!

c) Sample item of Interest in Mathematics Learning
Note: QO: qiuet often QS: qiuet seldom
O : often S : seldom

No.	Statement	QO	O	S	QS
1.	Math lessons are very interesting and fun				
2.	I was active in group discussions				
3.	I am often confused in group discussions				
4.	I pay attention to the teacher's explanation during the learning process				
5.	I relaxed with my school assignments at home				
6.	I worked on practice questions or assignments carefully				

3. Result and Discussion

Descriptions of Creative Thinking Abilities, and Interest in Learning Mathematics based on students' cognitive stages are attached in Table 1:

Table 1. Description of mathematical and creative thinking abilities interest in student mathematical learning by student cognitive levels

Variable	Statistics	Concrete Stage	n (%)	Transition Stage	n (%)	Formal Stage	N (%)	Total	n
CTA (IS=.36)	$\bar{x}$	14.25	45%	26.18	25%	31.98	30%	21	36 100%
	%	28.50%		52.36%		63.96%		42%	
	SD	6.67		1.53		2.71		10.09	
LI (IS =36)	$\bar{x}$	75.76		76.22		80.90		77.2	36 100%

From Table 1, we find the average score of middle-class CTA students at a concrete stage of 14.25 around 28.50%, while students at the transition stage obtain an average of 26.18 around 52.36% and students at the formal stage the average is 31.98 about 63.96%. If the CTA score of the formal stage student is higher than the CTA score of the transitional stage students and like that the CTA score of the transitional stage students is higher than the value of the student's concrete stage. CTA scores of formal, transitional, and concrete students are in a good level, middle level and low level respectively.

While LI scores for all students are at a fairly good level. According to the cognitive stage of students, there were no different LI scores between the formal stage students and the transition and their scores were at a fairly good level, and the scores of the two students were higher than the students' LI scores at the intermediate level.

Further analysis is about the difficulty in solving CTA questions among the student stages. The information is presented in Table 2. The researcher detected that concrete students realized more difficulties than the transitional stage and formal students in completing the CTA problem.

Table 2. Average value of each item of creative thinking ability according to the student cognitive stage

Cognitive Stage	Item number.	No.1	No 2.	No.3	No.4	N0. 5
	Ideal score	8	10	10	10	12
Formal	$\bar{x}$	6.74	8.40	6.50	4.68	5.60
	%	84.2%	84%	65%	46,8%	46,7%
Transition	$\bar{x}$	6.47	8.2	3.84	2.05	4.30
	%	80,8%	82%	38.4%	20,5%	35,8%
Concrete	$\bar{x}$	3.38	5,25	3.06	1.14	2.62
	%	42,2%	52,5%	30.6%	11.4%	21.3%

Creative Thinking Ability Ideal score CTA: 50

The findings from Table 2 are the superiority of formal students rather than students in the transition stage, and the superiority of the transitional stage students than the concrete stage students in CTA means that formal subjects are smarter than transitional and concrete subjects in compiling answers to mathematical questions that require formal operational competencies as in about the CTA.

However, there are different findings on LI, that there is no different LI score between students in the formal and transitional stages but both grades are higher than students' LI scores in the concrete stage. It is understandable because behaving LI is not directly influenced by the cognitive demands of the formal operational stage but by affective.

4. Conclusion

Based on the findings and discussion, this research concludes as follows. According to TOLT, the cognitive distribution of the eleventh grade with the age of around 17 years, is categorized as follows: 30% of students are in the formal stage, 25% of students are at the transition stage, and 45% of students are at the concrete stage. In the ability to think creatively in mathematics, all students are at the middle-class level.

According to the cognitive stage of students, the level of mathematical creative thinking ability of the formal stage students is higher than the transition stage students, and both are higher than the concrete stage students. Thus, concrete students realize many difficulties, transition stage students realize less difficulty and formal students realize the least difficulty in solving mathematical creative thinking skills.

In general, the findings regarding the distribution of students' cognitive stages and the superiority of formal stage students rather than students in the transition and concrete stages in solving mathematical creative thinking problems from this survey are solid with Inhelder and Piaget's Children's Cognitive Development Theory.

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