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CONTRIBUTION OF FORMAL THINKING ABILITY ON THE CONCEPT MASTERY OF KINEMATICS

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ABSTRACT

The main purpose of the study is to investigate contributing of formal thinking students' ability level to their mastery competence in physics. The purpose of this study is to examine integrated formal thinking abilities and the concept mastery of kinematics among freshment/ first year of physics education prospective teachers student and determine the relationship, if any, between the two. A relationship was thought to exist since both sets of skills strongly emphasize conducting fair experiments as well as other abilities. A measuring tool for collecting data of formal thinking skills and learning achievement physics are the Test of logic Thinking (TOLT) and the Test mastery of concepts shaped multiple choice. The both test were given to 36 students. Resulting correlations showed a a little relationship between achievement on the two measurements. Factor analysis data corroborate the correlational evidence. One potential inference to be drawn from these results is that problem solving skill teaching might be influenced formal thinking ability.

Keyword: *Formal Thinking ability, mastery competence in physics, Freshmen year student, Education prospective*

INTRODUCTION

The main objective of science education is to develop individuals to have scientific literacy and becomes a qualified human resource. Other way stated, the objective is to intellectually promote human .development as a rational being (Karsli *et al*, 2009). The main focus for the educators is to develop the scientific ability of the students in concept mastery, both inside and outside the classroom. Concept mastery ability is one main part in education, which increases the ability for abstraction, conceptual thinking, and generalization (Zhaoyao, in Santyasa 2006).

Mastery of conceptual knowledge is the basis for understanding, according to Anderson & Krathwohl, (2001) is a cognitive process in the category of understanding covering: interpreting, exemplifying, classifying, comparing), explaining, and (inferring). (1) Interpretation includes the conversion of the words so different words (eg, describe in their own words), the image of the words, the words be the image, so the number be words, words become numbers, not beam so the sound of music, and the like. Other names are translated, paraphrased, described, and clarified; (2) Exemplifying involves the identification of the principal characteristics of the concept or the general principles and use these characteristics to choose or make an example. Other names to illustrate and exemplify is to give an example; (3) Classifying), involves the process of detecting the main characteristics or patterns that correspond this characteristic to chose sampe; (4) Comparing, involves the process of detecting similarities and differences between two or more objects, events, ideas, problems or situations, finding one-on-one relationship between the elements and patterns on the objects, events; (5) Explaining, takes place when students can create and use causal models in a system. This model can be derived from theory or based on research or experience; and (6) Inferring include the process of finding patterns of a number of examples. Inferencing occurs when students can abstract a concept or principle that explains these examples to examine the characteristics of each example and, most importantly, with interesting relationship between these characteristics (Zhaoyao, in Santyasa 2006).

According to several researches, the learning process of science requires high level of reasoning ability, especially formal reasoning thinking. According to Krajcik & Hanet (1987):, there is a direct relation between formal thinking and integrated science process such as the ability to identify and control variables, and the ability to construct hypothesis (Tobin and Capie, 1982). Strong formal reasoning ability is expressed as a predictor of skill attainment process (Tobin and Capie, 1981). Relation between several variables and formal reasoning has been a concern for years in science education research. There are five aspects of the operation of formal reasoning, namely: proportional reasoning, control of variables, probability reasoning, correlation reasoning, and combinatorial reasoning. The fifth aspect has been identified as an important ability in order to achieve success in science and mathematics (Bitner 1991). Based on the importance, some authors suggest that the development of formal reasoning ability is a key priority in science education (Krajcik & Hanet, 1987; DeCarcer *et al*, 1978; Lawson, 1982). In fact, proportional reasoning, for example, is very important in many aspects of the science of quantitative reasoning without access to a proportional understanding of the derivation and the use of a large number of functional relationships in science is not achieved. This applies particularly in the construction and interpretation of tabulated data and graphs. Therefore, proportional reasoning leads to a good understanding of the derivation and use of functional relationships in science. Correlation reasoning becomes scientific research centers in all levels of education. It is essential in the formulation of hypotheses that consider potential relationships between variables. It is also important in the interpretation of data where the potential relationship between the variables is considered. Reasoning controls important variables in the planning, implementation and interpretation. Interpretation of data based on investigations, observations, or experiments often require probabilistic reasoning. And lastly, combinatorial reasoning occurs in the formulation of hypotheses alternative to test the effect of selected variables on the response variable. However, most of the elementary grade students do not have the ability to think like this. (Garnett and Tobin, 1984). In line with this idea, Johnson and Lawson (1998) examined the relative effects of reasoning ability and knowledge on biology achievement in expository and inquiry classes. They found the ability of reasoning to explain most of the variation in test scores in both learning methods. In addition, the ability of reasoning is found to be the best predictor of student achievement in solving genetic problems (Cavallo 1996; Mitchel and Lawson, 1988). Moreover, Lawson (1982) found a substantial correlation between formal reasoning and achievement in biology. Similarly, Chandran, Treagust and Topin (1987) showed that formal reasoning ability and prior knowledge was a significant predictor of performance on chemical calculations, laboratory applications, and contents of chemical knowledge.

According to Piaget (1972), there are four stages of growth of logical thinking from infancy to adolescence. The stages are: sensory-motor (age 0-2 years), preoperational (age 2-7 years), concrete operational (ages 7-11 years), and formal operational (age 11-16 years), representing a progressive organization and reorganization of experience to form mental structures which is able to accommodate new material and use it.

METHODOLOGY

This research was conducted in one of the Physics education program in North Sumatra for the first year students. The number of research subjects was 36 students with 26 women and 10 men. Data were collected through two research instruments, namely logical of thinking test (TOLT) and test of mastery concept of physics. Logical test (TOLT), originally developed by Tobin and Capie (1981), is used to determine students' formal reasoning abilities. TOLT psychometric characteristics were being well documented by the developers. This test was translated and adapted into Turkish by Geban, Askar, and Ozkan (1992) and the reliability was found to be 0.81. The test consists of 10 items designed to measure the proportional variables (items 1 and 2), reasoning control variables (items 3 and 4), probabilistic reasoning (items 5 and 6), correlation reasoning (items 7 and 8), and combinational reasoning (items 9 and 10). The form of the test consists of illustrations of problems and multiple choice answers and reasons, except for

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combinatorial reasoning. The Test mastery of concepts shaped multiple choice consisted of 4 alternative choices and contain of 30 items.

TOLT has been translated into Bahasa Indonesia by Sumarmo (in Haryanto, 2012) and is reported to be having a reliability of 0.66. According to Valanides (in Haryanto, 2012) the validity of this test, if compared with the interview model of Piaget in the form of interviews for secondary and college students are at 0,82. In order to further solidify TOLT in using the sample, tests were conducted with test samples from the same population to obtain the validity and reliability. By using ANATES software ver. 4.0.9, the test results obtained from the validity and reliability tests of 0.67 and 0.80. The form of the tests is concept mastery of physics in the form of objective test consisting 30 items. The questions of the test were thus tested, and its reliability was proven. Collected data were analyzed using Statistical Package for Social Sciences (SPSS). Prior to hypothesis testing, description of data is shown in the form of frequency, percentage, mean, standard deviation. Analysis of the data and the results are presented with particular reference to the research hypothesis: formal thinking skills affect the concept mastery of physics. The hypothesis was tested using simple regression analysis. In regression model, formal thinking ability is used as the independent variable, while the concept mastery of physics as the dependent variable.

RESULTS AND DISCUSSION

Calculations of descriptive of test of concept mastery of physics based on the interval classes are shown in Table 1.

From Table 1 we've shown that the calculations of descriptive are performed based on the condition, test of concept mastery of physics in overall concept, , Mean = 18.89; SD = 2, 84; Minimum score = 12; and the Maximum Score = 24. On the Interval Down On Group, Mean = 17, 6 and SD = 2, 68; On Interval Middle on Group, Mean = 20, 14 and SD = 2.07; and on Interval Upper on Group, Mean = 23, 00 and SD = 1, 41.

From the above statistics (Table 2), the scores of independent variables (formal thinking abilities) show the mean and standard deviation of 6.58 and 1.68. On the other hand, the dependent variable (concept mastery of physics) has the mean of 18. 94 and the standard deviation of 2,79

The result of score of formal thinking ability and concept mastery of physics are shown in Table 2

The relationship between formal thinking abilities (*X*) and concept mastery of physics (*Y*) from the calculation of the correlation coefficient of 0.133 is shown in Table 3.

Table 1. Calculations of descriptive of test of concept mastery of physics based on the interval classes

Type of Test	Group Based on Value	Test of Concept Mastery
Concept Mastery of Phyics		Mean = 18.89 SD = 2.84 Skor = 12 Min. = 24 Skor = 36 Max. N
Type of Test	**Group Based on Value**	
Test of Concept Mastery of Physics	Below	20
	Mean	17,6
	SD	2,68
	Middle	14
	Mean	20,14
	SD	2,07
	Upper	2
	Mean	23,00
	SD	1,41
	Total	36

Table 2. Result of formal thinking ability and concept mastery of physics

Descriptive Statistics

Source	Mean	Std. Deviation	N
Formal Thinking Ablity	6.58	1.68	36
Concept Mastery of Physics	18.94	2.79	36

Table 3. Correlation about of formal thinking ability and concept mastery of physics

Test by	Source	Parameter of statistic	Formal Thinking Ablity	Concept Mastery of Phyics
Spearman's rho	Formal Thinking Ablity	Correlation Coefficient	1.000	.133
		Sig. (2-tailed)	.	.439
		N	36	36
	Concpt Masteryof Phyics	Correlation Coefficient	.133	1.000
		Sig. (2-tailed)	.439	.
		N	36	36

From the result in Table 3, *N* denotes the number of observations/ sample of 36, whereas the correlation indicated by the number 0.133, which means that the magnitude of the correlation between the variables of formal thinking and concept mastery of physics is equal to 0.133. Meanwhile, the number of sig. (1-tailed) is 0.220. This value is greater than the critical threshold α of 0.01 that will means that there is no relationship between the two variables at a significance level of 0.01.

Based on the criteria of degree of difficulty, the correlation coefficient of 0.133 lies in the little category. This is to see whether there is a correlation between formal thinking ability with concept mastery of physsics. This is done to see whether the students who have the ability to think both formal and informal will obtain good troubleshooting results. To determine whether there is a relationship or association these variables, correlation technique is used.

Test of Hypothesis. The relationship between formal thinking abilities (*X*) with concept mastery physics (*Y*) was examined. From the calculation results obtained by simple regression analysis, a regression toward *b* = 21, 57 and a constant *a* =- 0.344 was obtained, resulting a regression equation: *y* = -0,344x + 21,570. The effect of formal thinking ability to concept mastery is shown in Figure 1.

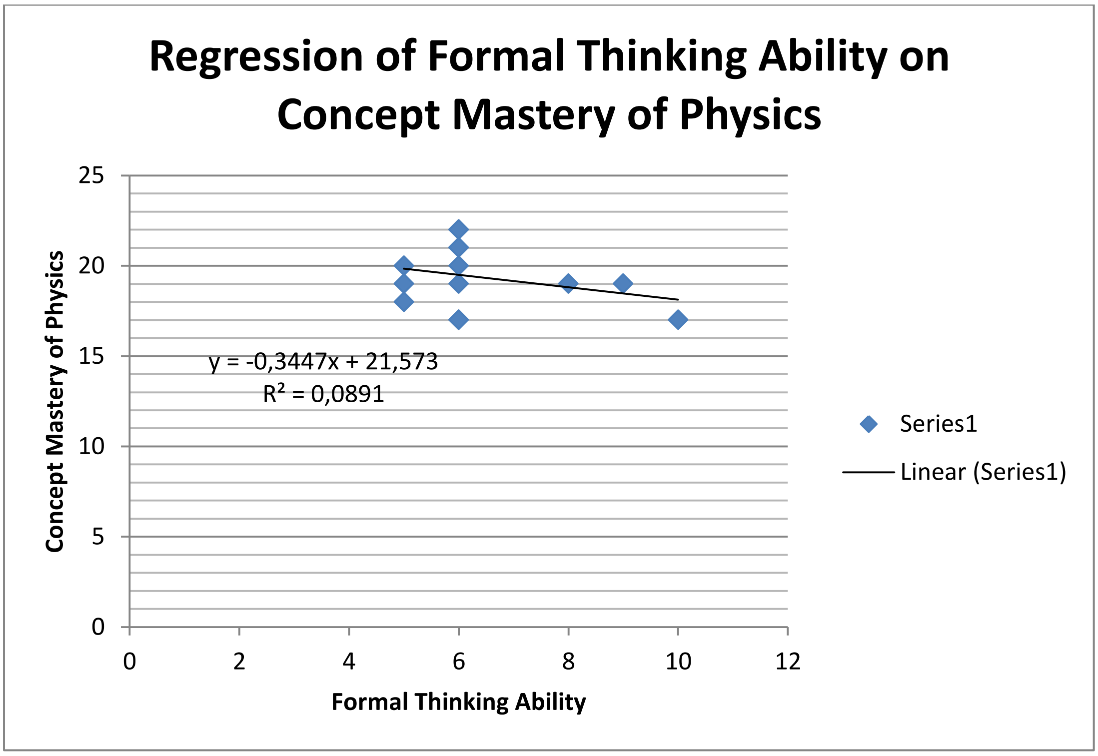

Figure 1. The resulting linear regression.

From the scatter plot, not the positive linear regression relationship for all points (*Y*, *X*) is obtained. The data scattered approximately in a form of a straight line and the two variables change not in the same direction. Thus, if the variable formal thinking abilities (*X*) rises, then the mastery concept of physics (*Y*) also rises a little.

To determine the significance and the linearity of the regression, ANAVA F-test was conducted, based on tests of concept mastery of physics and formal thinking ability as a predictor (independent variable/IV), as shown in Table 4.

Table 4. Calculation of ANOVA on Score of Concept Mastery of Physics

Sumber	Type III Sum of Squares	Mean Square	F	df	*P*	Conclusion
IV: Formal Thinking Ability	78.757	13.126	2.86	6	0.010	Significant
Error	204.798	4.59		29		
Total	13128			36		
Total of Correction	283.556			35		

R *squared* = 0.278 (*adjusted* R *squared* = 0.128)

ANOVA calculations showed that the of formal thinking can be a significant predictor in determining the concept mastery of physics. The results of the calculations indicated that the ability to think formally is proved to be a good predictor to determine the concept mastery of physics scores, $F(6.29) = 2.86$, $p = 0.010$, because of $F_{calculation} < F_{table}$ for 5 % error level, or 2.624 < 6.289. Thus, the use of a linear regression is confirmed.

Further testing with the *F*-test of significance of the calculations, it turns out the value of F is greater than F_{table}, then H_0 is rejected and H_a accepted. That is, there is a relationship between formal thinking skills and concept mastery of physics.

A high percentage (77.8 %) of the sample is in the early stages of formal reasoning, the final stage of formal reasoning by 19.4 %, and by 2.7 % in the transition phase. Classification of subjects in a stage of cognitive development is derived directly from the theory of Piaget. In other words, the need to classify subjects in a stage of cognitive development is not fully justified from the results of this study because the basic premise of Piaget's theory that formal reasoning is common in integrated mode and intellectual function not confirmed. Similarly, the test scores for the mastery concept of physics are as much as 47.2 % of students scored below average approximately, by 27.8 % of students got a score around the average, and as much as 52.87 % of students scored above the mean average.

The research results also show that the correlation between formal thinking skills and mastery is 0.133; concept of physics in a little category. If we consider the value of the coefficient of determination of 1,77 %, the positive relationship was contributed mainly by the variable formal thinking skills to students' ability to mastery concept of physics. In other words, the average value of 1,77 % mastery concept of physics is determined by the value of the given formal thinking skills, through the equation y = -0,344x + 21,570. Thus, according to Piaget's cognitive developmental factors, in particular the ability to think has a formal role important to improve academic achievement in learning. The second variable is the regression equation: y = -0,344x + 21,570 isn't linear. This equation shows the relationship between the proportional formal thinking skills with mastery concept of physics. That is, the higher the formal thinking skills of students, the more it will affect the growth of mastery concept of physics. This is supported by Gabel et al DeCarcer (1978) and Lawson (1982), who said that the development of formal reasoning ability is a key priority in science education, which can improve science process skills and understanding of concepts. This is evidenced by the research by Diniwati (2011) which states that there is a significant relationship between students' formal thinking skills with the ability to provide an overview of microscopic acid-base concept. Some important characteristics of formal thinking is the emergence of this ability to operate without the arguments associated with the empirical objects, the ability to see relationships using prepositions abstract and formal logic, as well as the emergence of the ability combinational ability to isolate individual factors or a combination of these factors that go on problem solving. The same thing is supported by research conducted Padilla (1983) which states that there is a correlation between the ability to think formally with science process skills by 0.73. Furthermore, Padilla (1990) proposed three strong arguments which emphasized the need and importance of science process skills activities in the classroom learning. The first is to generalize these skills lively. Secondly, more accurate skill activities reflects the nature of science and what scientists do. Thirdly, process skills activities involve development of formal reasoning ability. Stimulation of students' formal reasoning or thinking ability is another valuable goal of science education.

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