Development of Formal Reasoning Skills Through Subject Matter Calculus on Students Department of Mathematics Education and Natural Science Halu Oleo University

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Abstract

Purpose of this research is: (1) Develop a formal reasoning skill through subject matter calculus on students departement of Mathematics Education and Natural Science Halu Oleo University, and (2) Comparing formal reasoning ability and learning outcomes of students who are given formal reasoning skills and without learning formal reasoning. The Subjects were students of the first semester of the Department Mathematics Education and Science Halu Oleo University, consisting of 4 Study Program are: Mathematics Education there are 51 people, 54 people Physical Education, Biology Education there are 50 people, and there are 35 people of Chemical Education. Of the four courses above, Physical Education Studies Program to be a place of learning implementation of formal reasoning skills. TheResults of this research shows that the reasoning abilities of students departement of Education Mathematics and Natural Science Halu Oleo University has increased and generally already at the stage of combinatorics either through teaching or without formal reasoning skills. And, through the study of formal reasoning skills higher increase compared with no formal reasoning skills through learning. This means that the teaching skills of formal reasoning can accelerate the improvement of student reasoning abilities.

Keywords: Formal Reasoning skills, subject matter Calculus

1. Introduction

Generally, the first semester students in the Department of Mathematics Education and Natural Science Halu Oleo University in the first year have not been able to adjust to the programmed course. It can be seen from the average index of new student achievement in each year generally remained below 2.5. It is assumed that the poor performance is caused by a new student level of cognitive development they have not all of them are at the stage of formal operations. That assumption can be shown on the survey results of Formal Reasoning Ability first semester students Department of Mathematics Education and Natural Science Halu Oleo University as the following table 1.

Table 1: Preliminary data Formal Reasoning Ability Student Department of Mathematics Education and Natural Science Halu Oleo University

No.	level Reasoning	Mathematics		Physics		Chemistry		Biology	
		∑	%	∑	%	∑	%	∑	%
1.	Proportional	40	78,4	41	75,9	20	40	17	48,6
2.	Control of variable	28	54,9	11	20,4	11	22	15	42,8
3.	probabilistic	6	11,7	5	9,2	4	8	2	5,7
4.	Correlational	30	58,8	19	35,8	20	40	11	31,4
5.	Combinatorics	4	7,8	5	9,3	7	14	11	31,4
∑		51		54		50		35	
Mean		3,53		2,35		1,48		2,29	

Based on Table 1 above, it appears that the initial formal reasoning ability students the Department of of Mathematics Education and Natural Science Halu Oleo University prior to the lecture is still low and still at the stage of proportion. Therefore, for a particular semester student in the Department of of Mathematics Education and Natural Science Halu Oleo University very necessary given Formal Reasoning Skills teaching with the aim that they can adapt / follow easily the material on subjects that are programmed.

According Numedal S.G. (1991) that in general there are two models of Reasoning Skills are given to the students, namely providing courses of formal reasoning separately / stand alone, and formal reasoning skills training through the topic / content on a certain subject. Some psychologists agree to provide formal reasoning skills through a particular course, for reasons of time efficiency.

Theoretically, the ability of each individual reasoning is tiered based on the individual's level of development, and intellectual development of each individual tailored to

the child's age. This is consistent Piagiet theory (in Omrod, Jeanne Ellis, 2012) that each individual experience levels of intellectual development, namely: (a) The level of sensorimotor thinking; estimated age 0-2 years, (b) the level of pre-operational thinking; estimated age 2-7 years, (c) Level think concrete operations; estimated age 7-12 years, and (d) level of thinking of formal operations; estimated age 12 years and above. Of the four steps above, when taken in conjunction with the child's age and developmental level of formal education, the first semester students already at the stage of formal operations.

Furthermore, the formal operations also are the stages starting from a low level to a higher level. According Piagiet and Inhelder (in Muh.Nur, 1991: 5) that formal operations are classified into five types, namely:

a. Proportional Reasoning; According Piagiet Proportional Reasoning as a qualitative structure that enables understanding of complex systems-physical systems containing many factors. Understanding of complex physical systems is understanding relating to the proposition or ratio. For example, note the comparison between a and b is 3, a and c is 2. What is the comparison of a and c? To answer this question, the process of thinking of children are at proportional reasoning.
b. Controlling variables; According Piagiet, formal reasoning can set and control certain variables of the problem. For example, when children understand the conservation of such a pendulum motion, the pendulum can move quickly or slowly depending on the length of the rope.
c. Probabilistic Reasoning; According Piagiet Probabilistic Reasoning as a reasoning which uses the information to decide the possibility of right or wrong of a conclusion.
d. Reasoning correlations; According to Lawson Reasoning correlations as a thought pattern that is used for someone to break the strong reciprocal relationship between the two variables. Correlational reasoning involves the identification and verification of the relationship between variables.
e. Reasoning Combinatorics; According vantina Combinatorics reasoning is the ability to consider all possible alternatives in certain situations. Individuals who perform formal operations when solving a problem would be to use the whole combination / factors that might be related to the problem.

Based on the above, the authors have designed a material development of calculus by slipping formal reasoning skills. Form of formal skills developed in the calculus of teaching materials is a matter of adjusting the level of difficulty in the examples and exercises lead to the level of formal reasoning, ie, proportional reasoning, Control Variables, Probabilistic, correlations, and combinatorics. The introduction of formal reasoning skills will stimulate cognitive level so that students can improve their formal capabilities.

The issues to be achieved from the implementation of this study are: (a) What form of formal reasoning skills development through subject matter Calculus ?, (b). Are there differences in the results of formal reasoning skills of students between the application of formal reasoning and without formal reasoning skills in students Department of Mathematics Education and Natural Science Halu Oleo University?

2. Research Methods

1. **Subjects Research**

The research was conducted in the first semester students Department of Mathematics Education and Natural Science Halu Oleo University, consisting of 4 Study Program are: Mathematics Education there are 51 people, 54 people Physical Education, Biology Education there are 50 people, and there are 35 people of Chemical Education. Of the four courses above, Physical Education Studies Program to be a place of learning implementation of formal reasoning skills.

2. Research Instrument

To measure whether the child is located on the fifth stage of formal operations is through a test called the Formal Reasoning Ability Test (TKPF). This test is an adaptation of TOLF (Test of Logical Thinking) developed by Kenneth Tobin and William Cupic around 1980 and was first developed in Indonesia by Muh Nur 1991. This test consists of 10 items and measures five aspects of formal reasoning ability in above, namely items 1 and 2 measure proportional reasoning, items 3 and 4 measure pengotrolan variables, items 5 and 6 measure probabilistic reasoning, items 7 and 8 gauge correlational reasoning, as well as items 9 and 10 gauge reasoning combinatorics.

3. Data Collection Techniques

Before implemented learning student reasoning skills, first given formal reasoning ability tests (TKPF). This test aims to see more early formal reasoning ability of students from the Department Mathematics Education and Natural Science Halu Oleo University before getting a lecture. Furthermore, the learning undertaken reasoning skills through teaching materials Calculus student for one semester. After the end of the semester, students diteskan back test the ability of formal reasoning in the experimental class (Physical Education), which is to see an increase in formal reasoning ability of students after learning given formal reasoning skills. While other classes saw an increase in formal reasoning abilities of students after learning without learning given formal reasoning skills.

3. Research Results and Discussion

3.1. Research Results

a. Shape of Development Formal Reasoning Skills through Subject Matter Calculus

Development of formal reasoning skills through subject matter Calculus refer to the Calculus and Analytic Geometry book, written by Purcell. However, examples of questions and exercises adapted to the 10-point test in TKPF which represents the fifth stage of formal reasoning according Piagiat and Inhelder. The forms of teaching as follows.

1) Proportional reasoning.

The material taught: Inequality

Step by Step Learning:

a). Lecturer explains the notion of inequalities: linear, quadratic, and burst function, and give examples of each of these inequalities and how to determine the set of settlement.

b). Students are trained to solve problems of inequality with the changing forms of the equation of the examples given by the lecturer. Thus, in solving these inequalities students compare with the completion of the form given by the lecturer.

The shape of the sample questions of the lecturer:

- $x + 4 \geq 1$ (linear inequalities)
- $x^2 - x - 12 < 0$ (quadratic inequalities)
- $\frac{x-4}{x+1} > 0$ (inequality burst function)

Forms of matter which trained students

- $3x - 4 < x+6$

- $2x^2 + x - 6 > 0$
- $\frac{x+3}{x-2} < 2x+1$

2) Controlling variables.

The material taught: Absolute Value

Step by Step Learning:

a). Lecturers explain the meaning and properties of the Absolute Value.

b). Students are trained to solve problems based on the absolute value of the definition and properties of the Absolute Value

Definition of Absolute Value: $|x| = \begin{cases} x, x \geq 0 \\ -x, x < 0 \end{cases}$

The properties of the absolute value: 1. $|x| < a \leftrightarrow -a < x < a$

2. $|x| \geq b \leftrightarrow x \leq -b$ or $x \geq b$

Forms of matter are trained:

Determine the set of settlement of:

- $|x| + 4 < 3$ (using the definition of the absolute value)
- $|x + 2| \geq 1$ (using the properties of the absolute value)
- $|x - 3| > |x + 2|$ (using the definition and properties of the absolute value)

3) Probabilistic Reasoning

The material taught: Straight Line Equations and Graphs

Step by Step Learning:

a). Lecturer explain the meaning of straight lines and steps to draw graphs of equations.

b). Students are trained to determine the form of the equation and draw a straight line graph of the equation by choosing the right among the forms straight line equation and the graph of the equation that has been prepared.

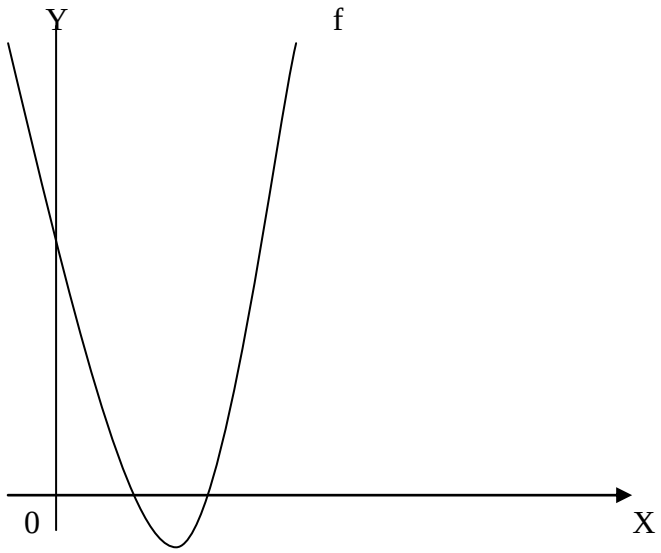
Forms of matter are trained:

(1). Among forms a straight line following equation, which is it?

(a) $y = 4(x-1)$ (c) $y = 5$ (e) $y = 3 - 4x$

(b) $y = 0x + 1$ (d) $y = 100x$

(2).



Form of the equation that satisfies the above chart is

(a) $y = ax^2 + bx + c$; $a > 0$, $D > 0$

(b) $y = ax^2 + bx + c$; $a > 0$, $D < 0$

(c) $y = ax^2 + bx + c$; $a < 0$, $D > 0$

(d) $y = ax^2 + bx + c$; $a > 0$

(e) $y = ax^2 + bx + c$; $D > 0$

4) Reasoning correlations

The material taught: Functions and Graphs

Step by Step Learning:

a). Lecturer explains the notion of function, types of functions, and how to draw graphs of functions.

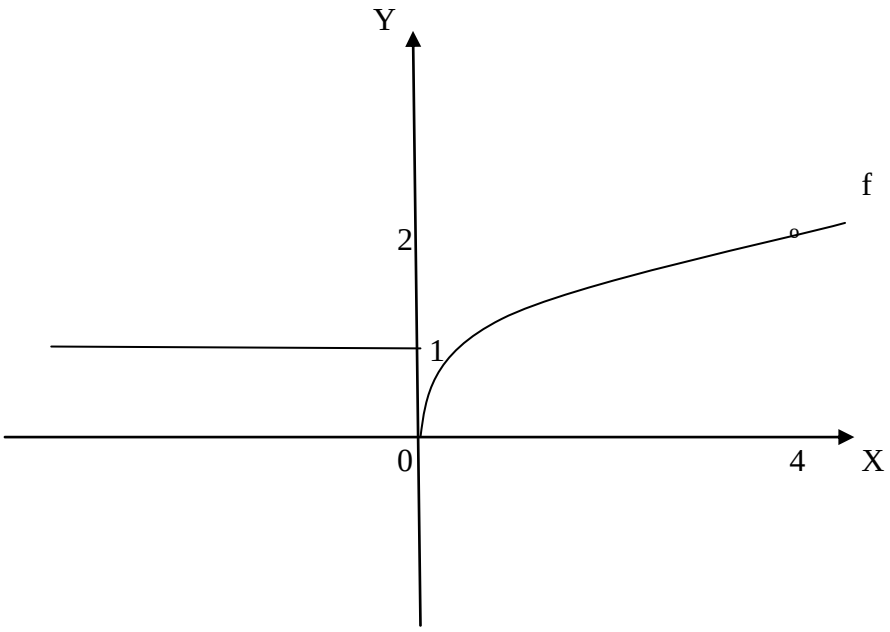
b). Students are trained to associate the relationship between understanding the function of the graph of a function or vice versa, based on the domain, codomain, and range.

Forms of matter are trained:

(1). Unknown function $f(x) = \begin{cases} x^2, x \geq 2 \\ x+1, x < 2 \end{cases}$

If f (x) a function? Draw the graph.

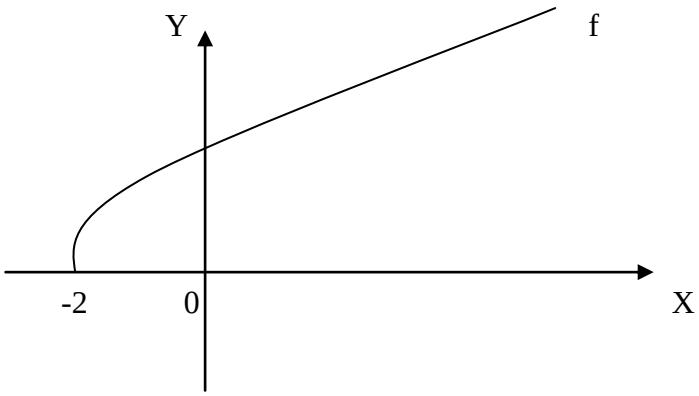
(2). A graph-shaped



Is the above graph is a function? Write the equation.

(3). Determine the domain and range of functions f(x) = $\sqrt{x+1}$

(4). Determine the domain and range of a function whose graph is as follows:



5) Reasoning Combinatorics

Material: Trigonometry Functions

a). Lecturer explain the meaning Sinus, Cosinus, and tangent along with its properties.

b). Students are trained to determine the likely size of the angle that occurs when the value of Sinus, Cosinus, and tangent is known, and vice versa.

Forms of matter are trained:

(1) Determine the price of x that satisfy if:

(a) Sin x = ½ (c) Tg x = 1

(b) Cos x = ½√2

(2). Determine the possible values of sinus, cosinus, and tangent that occur from:

(a) Sin k(30)▫, if k = 1,2,3, … ,n.

(b) Cos k(60)▫, if k = 1,2,3, … ,n.

(c) Tg k(135)▫, if k = 1,2,3, … ,n.

b. Results of Development Formal Reasoning Skills in the First Semester Students Department of Mathematics Education and Natural Science Halu Oleo University

It has been stated above that the implementation of the development of Formal Reasoning Skills in Physical Education Study Program, while three other programs without teaching Formal Reasoning Skills. The Formal Reasoning Ability test results after the implementation of lectures using formal and teaching skills without formal reasoning skills instruction, such as the following table.

Table 2: Data of Formal Reasoning Ability Student Department of Mathematics Education and Natural Science Halu Oleo University After Learning

No.	level Reasoning	Mathematics		Physics		Chemistry		Biology	
		∑	%	∑	%	∑	%	∑	%
1.	Proportional	41	80,4	**41**	**75,9**	20	40	17	48,6
2.	Control of variable	30	58,8	**17**	**31,5**	12	22,2	17	48,6
3.	probabilistic	10	19,6	**12**	**22,2**	2	4	6	17,1
4.	Correlational	35	68,6	**46**	**85,2**	21	42	24	68,6
5.	Combinatorics	40	78,4	**48**	**88,9**	30	60	20	57,1
∑		51		**54**		50		35	
Mean		4,37		**4,76**		2,17		2,94	

4. Discussion of Research Results

Sample questions and exercises in learning formal reasoning through calculus teaching materials conform with the fifth stage of formal reasoning according Piagiat and Inhelder.

The first form of matter (proportional reasoning); Forms of learning, the lecturer gives examples of the inequality topic complete with its completion. Students are trained to resolve the problem by changing the shape of the sample questions provided by the lecturer. So that students can compare the form of completion sample questions given by lecturers with

problem solving was doing. When students are trained and able to resolve the matter, the form of student reasoning stage already at the stage proporsiaonal according Piagiet and Inhelder.

he second form of matter (reasoning control variable); Forms of learning, the lecturer explain some definitions, theorems, and certain properties within a topic absolute value. Students are trained to solve problems in the topic based on the understanding of the definition or the properties of a particular concept. When students are trained and able to complete the form about by definition and properties of a particular concept or variable then reasoning stage students already at the stage of control variables according Piagiet and Inhelder.

The third form of matter (probabilistic reasoning); Forms of learning, lecturers provide learning to students about the meaning of some topic calculus. Students are trained to determine the positive examples and negative examples of elements of the topic based on the results of his own thoughts. When students are trained and able to determine the positive examples and negative examples of elements of the topic based on the results of his own thinking reasoning stage students already at the stage probabilistic according Piagiet and Inhelder.

The fourth form of matter (correlational reasoning); Forms of learning, teaching faculty provide feedback to students to flip between questions and answers, for example: (1) to draw the graph of a function when a certain unknown function, and vice versa specify a particular function when the graph function is known, (2) determine the domain and range based on the equation functions and graphs based on specific functions. When students are trained and able to connect on a reciprocal basis between drawing graphs of functions and certain functions of the equation reasoning stage students already at the stage of correlational reasoning according Piagiet and Inhelder.

The fifth form of matter (reasoning combinatorics); Forms of learning, lecturers provide learning to students in a particular topic, then students are trained to determine several possible correct answers of a problem based on the results of his own thoughts. When students are trained and able to determine several possible correct answers of a problem based on the results of his own thinking reasoning stage students already at the stage of the combinatorial reasoning according Piagiet and Inhelder.

Based on data tebel 2, when viewed average value and the percentage of each stages of formal reasoning on each program of study has been increased compared with the beginning of formal reasoning ability, and general reasoning student has reached a stage

penlaran combinatorics. This means, giving lectures on the subject is given a certain kind of formal reasoning skills and without learning formal reasoning skills have improved formal reasoning abilities of students. Similarly, when viewed in the magnitude of the increase in the average value and the percentage of each of the stages of formal reasoning on each of the study program Physical Education courses is higher compared to other courses in the Department of Mathematics Education and Natural Science Halu Oleo University. This means of development Formal Reasoning Skills through subject matter Calculus can accelerate the increase in reasoning ability student Department of Mathematics Education and Natural Science Halu Oleo University

As a result of the implementation of learning in addition to formal reasoning can improve formal reasoning ability students can also improve math learning outcomes. This is consistent with the results of La Misu (2003) that the learning outcomes of students in subjects who were given learning Calculus formal reasoning skills higher than conventional learning. However, the authors do not explore the link between the stages of formal reasoning skills by Peagiet and Inhelder with cognitive stages according to Bloom's Taxonomy.

5. Conclusions

Based on the above discussion, it can be concluded that

1. Form of development formal reasoning skills through specific materials is to train students with problems of specific teaching materials to follow the stages of formal operations proposed by Piagiet and Inhelder.
2. Development of Formal reasoning skills through specific materials can accelerate the increase in formal reasoning ability and learning outcomes of students from the Department of Mathematics Education and Natural Science Halu Oleo University.

Based on the above results, it is suggested to the Guidance and Counseling Department of Mathematics Education and Natural Science Halu Oleo University that teaching materials given to students tuck questions that have high reasoning power because it can speed up the formal ability students. Thus, also can improve student learning outcomes.

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