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CONNECTION AND MATHEMATICAL DISPOSITION TOWARD ADVANCED MATHEMATICAL THINKING IN APOS MATHEMATICS LEARNING

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Abstract: This study aimed to analyze the effect of mathematical connection and mathematical dispositions of students towards Advanced Mathematical Thinking in APOS mathematics learning and the most influence on Advanced Mathematical Thinking. This research is quantitative research. The data analysis used multiple linear regression. Variables in the research include dependent variable was the Advanced Mathematical Thinking and independent variables were mathematical connection and mathematical disposition. The research was conducted at the University of Kanjuruhan Malang, Faculty of Science and Technology in Mathematics Education. The respondents were Mathematics Education students who took a course in calculus (limit), the number of students was 30. The results of the research showed that mathematical connections and mathematical dispositions effect on Advanced Mathematical Thinking in APOS mathematics learning with percentage of 88,2%; From those results it can be concluded that mathematical connection and mathematical dispositions influence the Advanced Mathematical Thinking in APOS mathematics learning

Keywords: **Mathematical Connection, Mathematical Disposition, Advanced Mathematical Thinking, APOS Mathematics Learning**.

INTODUCTION

Mathematics is indispensable to the thinking activity. Thinking is a mental process that goes beyond remembering and comprehending (Sagala, 2003; Suryadi, 2012). Students' understanding of the connections between concepts or ideas of mathematics can facilitate their ability to formulate and verify the conjecture inductively and deductively and very important in the learning of mathematics. Furthermore, concepts, ideas and newly developed mathematical procedure can be applied to solve other problems in mathematics or other disciplines (Permana & Sumarmo, 2007; Wahyudin, 2008).

Mathematics learning in college-level requires the students to have the ability to think mathematically, so that students do not just memorize formulas or simply apply a mathematical formula. Mathematical thinking in college-level is advanced mathematical thinking. Sumarmo (2011) states that Advanced Mathematical Thinking certainly contains a high level of mathematical thinking. But not all high-level mathematical thinking contains advanced mathematical thinking.

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Advanced mathematical thinking is regarded to the introduction of formal definitions and logical deduction. Advanced Mathematical Thinking Process (AMT) consist of: the representation process, abstraction process, the relationship between representation and abstraction (Dreyfus (Tall, 2002); Sumarmo, 2011). Several studies, including (1) Herlina (2015) in her research stating that there were improvement on students' Advanced Mathematical Thinking (AMT) through APOS learning approach; (2) Suprayana (2012) in his research states that learning mathematics for higher level is not easy, so it takes time to understand mathematics as the logic language and has the ability to representing, abstracting, connecting representation and abstraction, creative thinking, and prove the more complicated facts covered in advanced mathematical thinking skills (AMT); (3) Smith (2004) in her study stated that students should be able to make a shift in Advanced Mathematical Thinking (AMT) to enable the harmonious relationship between the Elementary mathematical thinking (EMT) with Advanced Mathematical Thinking (AMT).

Tall (1999) in his research states that APOS theory has many applications in basic math arithmetic, algebra, and calculus. Advanced Mathematical Thinking needs expression in the actions, objects and schema. Asiala et al., (1997) suggest that there is interaction between students through APOS approach so an exchange of different learning experience is expected therefore mental action can be continued as expected, that has the ability to reflect on the actions that had been done, and students can reached the stage of potential development. Dubinsky & McDonald (2001) states that the theory APOS is an approach to learning that is generally performed for the learning of mathematics at the college level, which integrates the use of computers, discussions in small groups, and pay attention to mental constructions that is undertaken by students in understanding a math concept. The mental constructions are: action, process, object, and the schema which is abbreviated by APOS.

In solving mathematical problems, students are required to have mathematical connection capabilities. This is in accordance with the opinion of (Micovich & Monroe, 1994; NCTM, 2000) who state that there are three kinds of mathematical connections, namely; connections between mathematical topics, connections with other scientific disciplines and the connection with the real world. The ability of mathematical connection has purpose to recognize and use connections between the ideas of mathematics, understand how ideas of mathematical interconnected to produce a coherent (united), identify and apply mathematics both within and outside the context of mathematics (NCTM, 2000). Furthermore, concepts, ideas and newly developed mathematical procedure can be applied to solve other problems in mathematics or other disciplines (Permana & Sumarmo, 2007; Wahyudin, 2008). Mathematical connection ability is the ability to associate mathematical knowledge possessed by students with other mathematical ability and life realities (Ruspiani, 2000; Bahr & Garcia (2010)).

In addition to mathematical connections in enhancing Advanced Mathematical Thinking (AMT), students are required to have a mathematical disposition. Mathematical disposition is an interest and appreciation of mathematics such as the tendency to think and act positively, including self-confidence, curiosity, perseverance, enthusiasm in learning, persevering in facing problems, flexible, willing to share with others and reflective in the activities of mathematics (NCTM, 2000; Wardani, 2009). Measuring mathematical disposition with indicators: indicating passion / enthusiasm in learning mathematics, indicating a serious concern in learning mathematics, showing tenacity in facing problems, indicating confidence in learning and solving problem, showing high curiosity, demonstrating the ability to share with others (Syaban, 2009).

There are lot students who still do not have possitive attitude or a positive outlook on mathematics. The reality is consistent with several studies include Herlina (2013) who states

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that the disposition of mathematics increases with the learning of mathematics. With regard to the mathematical disposition which is still low, then the mathematical dispositions can be developed through the study of mathematics.

From the description and the above phenomena, efforts to improve the quality of learning by innovating the learning of mathematics through APOS associated with the mathematical connection and mathematical disposition, and formulation of the problem is there any effect of students' mathematical connections and mathematical disposition toward Advanced Mathematical Thinking in APOS mathematics learning? The purpose of this study is to analyze the effects of students' mathematical connections and disposition of toward Advanced Mathematical Thinking in APOS mathematics learning

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METHOD

The methods in this study focuses on the purpose of research is to analyze the effect of students' mathematical connections and disposition toward Advanced Mathematical Thinking in mathematics APOS. This research is quantitative and the variables in this study are: (a) The independent variables are: mathematical connections as (x_1) and mathematical disposition as (x_2); (b) The dependent variable, namely Advanced Mathematical Thinking (AMT) as (y).

The research was conducted at the University of Kanjuruhan Malang, Faculty of Science and Technology, Mathematics Education Department. The respondents in the study were students of Mathematics Education Department, Faculty of Science and Technology, University of Kanjuruhan Malang who took a course in calculus (limit), the number of students was 30. The research instrument is content validity by a senior lecturer of mathematics education. The data analysis used multiple linear regression analysis with SPSS assited, the stages are: (a) Validity and Reliability; (B) Test requirements analysis is multicollinearity test, autocorrelation test, heteroscedasticity test, test for normality; (C) hypothesis test that test the regression line through the R^2, with a significance test F test, significance test with t test; (D) Draw conclusions from the analysis of data.

FINDINGS AND DISCUSIION

The analysis of the effect of students' mathematical connections and disposition toward Advanced Mathematical Thinking in mathematics APOS using multiple linear regression analysis with SPSS aided covering validity and reliability, the prerequisite test analysis and test of hypotheses.

1. Test Validity and Reliability

Validity and reliability is test of data instrument that is used to determine the accuracy and consistency of measuring devices using a scale, questionnaires. Validity and reliability with SPSS aided by the analysis as follows:

a. Test Validity and reliability of mathematical connections, namely:
   (i) Output case processing summary is to explain the amount of valid data to be processed and the data are released. The valid data is 30 with a percentage of 100%.
   (ii) Output reliability statistics as a result of the analysis of reliability with cronbach alpha technique with cronbach alpha value is 0,833. The Results of cronbach alpha is 0,833 higher than 0,8 then the entire item is reliable.

b. Test Validity and reliability of mathematical disposition:

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(i) Output case processing summary is to explain the amount of valid data to be processed and the data are released. The valid data is 30 with a percentage of 100%.
(ii) Output reliability statistics as a result of the analysis of reliability with cronbach alpha technique with cronbach alpha value is 0,892. The Results of cronbach alpha is 0,892 higher than 0,8 then the entire item is reliable.

c. Test Validity and reliability of Advanced Mathematical Thinking (AMT), including:
(i) Output case processing summary is to explain the amount of valid data to be processed and the data are released. The valid data is 30 with a percentage of 100%.
(ii) Output reliability statistics as a result of the analysis of reliability with cronbach alpha technique with cronbach alpha value is 0,871. The Results of cronbach alpha is 0,871 higher than 0,8 then the entire item is reliable.

The results of Validity and reliability showed that the mathematical connection, mathematical disposition and Advanced Mathematical Thinking (AMT) in mathematics APOS declared valid and reliable, so that the instrument can be used for data retrieval in research.

2. Prerequisites Test Analysis

Prerequisite test multiple linear regression analysis with SPPS aided include multikoliearitas, autocorrelation, heteroskedasticity and normality as follows:

a. Multikolinearitas, can be seen the value of tolerance and inflation factor (VIF), namely: the output coefficients show that the value of tolerance for both variables is more than 0.10 with details ie mathematical connection with tolerance value is 0.991 and mathematical disposition tolerance value of 0.991. VIF value for the variable mathematical connections at 1,009 and VIF for variable mathematical disposition of 1.009 which means whole VIF obtained less than 10. It can be concluded that there is no multicollinearity between independent variables. It can be concluded that there is no multicolinearity between variables. It can be seen in the table below:

Tabel 1. Coefficients

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	-2.938	2.398		-1.225	.231		
	Koneksi Matematis	.463	.182	.169	2.551	.017	.991	1.009
	Disposisi Matematis	.353	.025	.940	14.159	.000	.991	1.009

a. Dependent Variable: Advanced Mathematical Thinking (AMT)

b. Autocorrelation, using the Durbin-Watson test is the model output summary that indicates that the Durbin-Watson value is 2,195. Durbin-Watson is 2,195 compared with the criteria for acceptance or rejection is made with d_L and d_U value is determined based on the number of independent variables in the regression model (k) and the number of samples (n). The result of output model summary with Durbin-Watson value 2,195 is less than 1,57 $(d_U = 1{,}57)$ and less than 2,43 $(4 - d_U = 4 - 1{,}57 = 2{,}43)$ it means that is the the area of no autocorrelation, thus it can be concluded that there is no autocorrelation. It can be seen in the table below:

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Table 2. Model Summary

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.939[a]	.882	.873	1.569	2.195

a. Predictors: (Constant), Disposisi Matematis, Koneksi Matematis

b. Dependent Variable: Advanced Mathematical Thinking (AMT)

c. Heteroskidastity, using the correlation coefficient Spearman's rho, in the output correlations which shows that the correlation between the independent variables they are mathematical connection with unstandardized residuals have a significance value greater than 0,844 and mathematical disposition with unstandardized residuals have significance value 0.870, which means the significance value greater than 0.05 it can be concluded that there is no heteroscedasticity problem. In addition to the heteroskedastisitas, testing methods of correlation coefficient Spearman "s rho also through observing at the pattern of dots on a scatterplot graph. Output scatterplot on a scatterplot graph show that hot spots do not form a pattern (a certain) groove and the dots spread both above and below the number 0 on the *y* axis. So it can be concluded that there is no heteroscedasticity in the regression. It can be seen in the table below:

Table 3. Correlations

Correlations

			Unstandardized Residual	Koneksi Matematis	Disposisi Matematis
Spearman's rho	Unstandardized Residual	Correlation Coefficient	1.000	-.038	.031
		Sig. (2-tailed)	.	.844	.870
		N	30	30	30
	Koneksi Matematis	Correlation Coefficient	-.038	1.000	-.100
		Sig. (2-tailed)	.844	.	.599
		N	30	30	30
	Disposisi Matematis	Correlation Coefficient	.031	-.100	1.000
		Sig. (2-tailed)	.870	.599	.
		N	30	30	30

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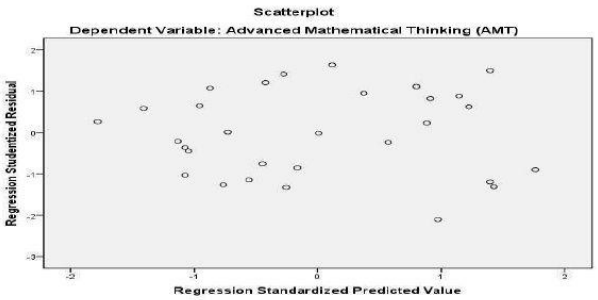
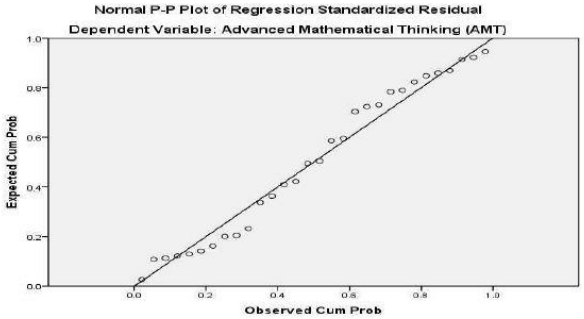


Picture 2. Scatterplot

d. Normality, using Normal P-P Plot graphs illustrate normality output that shows dots do not lie more or less in a straight line, so it can be concluded that residual data is normally distributed. It can be seen in the table below:



Picture 3. Normal P-P Plot

The results of prerequisite test analysis can be concluded that the mathematical connection, the mathematical disposition and Advanced Mathematical Thinking (AMT) in mathematics APOS fulfill the prerequisite of the linear regression that is no multikolinearitas, no autocorrelation, no heteroskedastisitas and normally distributed, so that the instrument can be used for data retrieval in research.

2. Hypothesis Testing

Analysis of hypothesis testing with multiple linear regression output aided by SPSS includes the F test and t test as follows:

a. *F* test, it can be seen from the output of ANOVA (analysis of variance) is a regression test together the significance effect of the connection variables influence how much mathematical and mathematical disposition toward the Advanced Mathematical Thinking (AMT) in the learning of APOS mathematics by testing using a 0,05 significance level. Analysis of ANOVA output includes:

(i) The percentage of the effect of mathematical connections and mathematical disposition toward Advanced Mathematical Thinking in APOS mathematics learning is 88.2%.

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(ii) Probability value of Anova Output data shows that significance $< 0{,}05$ is $0{,}000 < 0{,}05$ then H_0 rejected.

(iii) The conclusion is mathematical connections and mathematical disposition simultaneously affect the Advanced Mathematical Thinking (AMT).

It can be seen in the table below:

Table 4. Model Summary

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.939[a]	.882	.873	1.569	2.195

a. Predictors: (Constant), Disposisi Matematis, Koneksi Matematis

b. Dependent Variable: Advanced Mathematical Thinking (AMT)

Taeel 5. Anova

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	497.511	2	248.756	101.015	.000[a]
	Residual	66.489	27	2.463		
	Total	564.000	29			

a. Predictors: (Constant), Disposisi Matematis, Koneksi Matematis

b. Dependent Variable: Advanced Mathematical Thinking (AMT)

b. The multiple linear regression equation from the output coefficients indicate that the multiple linear regression model to estimate the effect of mathematical connections and mathematical disposition toward the Advanced Mathematical Thinking (AMT) in the learning of APOS mathematics is: $y = -2{,}398 + 0{,}463x_1 + 0{,}353x_2$. It can be seen in the table below:

Table 6. Coefficients

Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	-2.938	2.398		-1.225	.231		
	Koneksi Matematis	.463	.182	.169	2.551	.017	.991	1.009
	Disposisi Matematis	.353	.025	.940	14.159	.000	.991	1.009

a. Dependent Variable: Advanced Mathematical Thinking (AMT)

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c. T test, it seems from the output coefficients show partial regression coefficients test used to determine partially the mathematical connection and mathematical disposition significantly affect the Advanced Mathematical Thinking (AMT) in mathematics. The Test using a significance level of $0,05$ with the analysis:

(i) The test of mathematical connection Variable toward Advanced Mathematical Thinking (AMT)
  (a) Probability Value of Output coefficients showed that the significance $< 0,05$ is $0,017 < 0,05$ then H_0 rejected.
  (b) The conclusion is mathematical connections effect Advanced Mathematical Thinking (AMT) in APOS mathematics learning.

(ii) Coefficient testing of mathematical disposition variable toward Advanced Mathematical Thinking (AMT)
  (a) Probability Value of Output coefficients showed that the significance $< 0,05$ is $0,02 < 0,05$ then H_0 rejected.
  (b) The conclusion is mathematical disposition effect Advanced Mathematical Thinking (AMT) in APOS mathematics learning.

The results of Hypothesis test show the data of the effect of students' mathematical connection and mathematical disposition toward Advanced Mathematical Thinking in APOS mathematics learning as follows:

1. The effect of students' mathematical connection toward Advanced Mathematical Thinking in APOS mathematics learning can seen from the output coefficients by t test and the test using a significance level of 0,05. The Output coefficients result significant value is 0,017 compared to the 0,05 thus the significance$< 0,05$ for $0,017 < 0,05$ so H_0rejected. Thus it can be concluded that mathematical connections significantly affect the Advanced Mathematical Thinking (AMT). This is in accordance with the opinion (Ratnaningsih, 2003; Lasmanawati, 2011) that through the process of mathematical connection thus the students' thinking concept and insight on mathematics is getting wider, not only focused on the topic being studied. Additionally, Wahyudin (2008) also found that a good mathematical connection capability result in the high mathematics skills.
2. The effect of students' mathematical disposition toward Advanced Mathematical Thinking in APOS mathematics learning can seen from the output coefficients by t test and the test using a significance level of 0,05. The Output coefficients result significant value is 0,02 compared to the 0,05 thus the significance$< 0,05$ for $0,02 < 0,05$ so H_0 rejected. Thus it can be concluded that mathematical disposition significantly affect the Advanced Mathematical Thinking (AMT). This is in accordance with the opinion of Syaban (2009) which concluded that overall the increase of mathematics disposition of students who receive teaching with model or a particular approach is better than the students who receive conventional learning.
3. The effect of students' connection and disposition toward Advanced Mathematical Thinking in APOS mathematics learning seen from the output of ANOVA (analysis of variance) that is a simultaneous regression test (F test) and test using 0.05 significance level. Anova output significance is 0,000 compared to the 0.05thus significance $< 0,05$ for $0,000 < 0,05$ so H_0 is rejected. Therefore it can be concluded that the mathematical connections and disposition simultaneously influence on Advanced Mathematical Thinking (AMT).
4. Multiple linear regression equation to estimate the effects of mathematical connections and mathematical disposition toward Advanced Mathematical Thinking (AMT) can be seen

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from the output coefficients which indicate that the model of multiple linear regression equation is $y = -2{,}398 + 0{,}463x_1 + 0{,}353$. Multiple linear regression equation can be used as a basis to estimate the ability of Advanced Mathematical Thinking (AMT) is affected by mathematical connections and mathematical disposition. The percentage of the effect of mathematical connections and disposition toward Advanced Mathematical Thinking in APOS mathematics learning is 88.2%.Thus it can be concluded that the mathematical connections and disposition of simultaneously affect on the Advanced Mathematical Thinking (AMT). In this regard, to improve the ability of Advanced Mathematical Thinking (AMT) then the ability to connect and mathematical disposition should be improved.

CONCLUSIONS AND SUGGESTIONS

The results of data analysis and discussion that has been presented can be concluded that mathematical connections and mathematical disposition effect on the Advanced Mathematical Thinking in APOS mathematics learning. The percentage of the effect of mathematical connections and mathematical disposition toward Advanced Mathematical Thinking in APOS mathematics learning is 88.2%.

With regard to the results of these studies, the few things that need to be considered as a suggestion in achieving the goals of mathematics learning that the lecturers are expected to provide mathematical problems related to the mathematical connections so that students have Advanced Mathematical Thinking ability and give students the opportunity to connect mathematically so that students can solve mathematical problems well. Further research is considered necessary so that the expected results of this study can be used as reference both theoretically and practically in enhancing the ability to think mathematically.

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