

The Influence of Independent Learning and Structure Sense Ability on Mathematics Connection in Abstract Algebra

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The Influence of Independent Learning and Structure Sense Ability on Mathematics Connection in Abstract Algebra

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Abstract—This study aimed to reveal the influence of independent learning and structure sense ability on mathematics connection in abstract algebra through mentoring modules as an initial step to overcome the students' difficulties in learning and to habituate students to recognize the structure sense and mathematics connections through weekly tasks. This research was conducted at the fifth-semester students of the Mathematics Education Study Program for 7 weeks. A quantitative research design with two independent variables (independent learning and structure sense ability) and one dependent variable (mathematics connection ability) was employed in this study. This study took 26 students for the sample. The data to measure independent learning was gathered through a questionnaire; the data to recognize the structure sense ability was gathered through weekly tasks, and the students' mathematics connections were measured through a test. The results of simple regression and multiple regression analyses, simultaneously with independent learning and structure sense variables, affect students' mathematics connection ability in abstract algebra course. The results indicate that independent learning is more dominant than structure sense ability in influencing students' mathematics connection ability. Thus, in order to achieve high mathematics connection abilities, students should, first, have high independent learning, and then develop the ability to recognize structure sense.

Keywords: independent learning, structure sense, mathematics connection, abstract algebra

I. INTRODUCTION

It is expected that authors will submit carefully. The importance of building the character of independent learning is to meet the demands of Presidential Regulation Number 87 in the year 2017, and the demands of the 21st-century in learning mathematics. One of the central character values that originate from *Pancasila*, which are prioritized for the development of character building, is independent learning. Independent learning is an attitude and behaviour that does not depend on others and use all energy, thoughts, and time to realize hopes, dreams and ideals. Students who have

independent learning have a good work ethic, robust, empowered, professional, creative, courage, and become lifelong learners [1].

There are four mathematical skills developed in the 21st-century era, i.e., critical thinking skills, creative thinking skills, communication skills, and collaboration skills [2]. From these 4 pillars, a bachelor student should refer to, at least, mastering theoretical concepts in specific fields of knowledge and skills in general and theoretical concepts specifically in the field of knowledge and skills deeply [3].

Problem-solving and independent learning skills are two skills that should be owned by students in learning physics at the college level [4]. It is based on the characteristics of physics material that are considered difficult and complicated. Therefore, they developed a Book entitled 'Model Physics Independent Learning' (PIL) to improve problem-solving skills and students' independent learning skills [4].

Several learning approaches have been carried out in order to develop independent learning skills through a lecture contract approach and to improve the students' independence, as well as mathematics learning outcomes in the material of differential calculus with the Snowball Drilling method has an average score of 81.62% with minimum completeness of 89.74% [5] [6].

Through independent learning, a student will be able to determine the steps that must be taken in learning, able to obtain self-learning resources, and able to conduct self-evaluation activities and reflection on learning activities that have been carried out in abstract algebra course [7]. Further, [8] states that reciprocal teaching-learning is better than a facilitator model in fostering students' independence in learning mathematics. These habits become one of the reasons to increase other factors such as the awareness of learning and the sensitivity to structure sense which becomes an important part of abstract algebra course.

Yerizon [9] reviewed students' independent learning in the Real Analysis course with modified APOS approach. The result shows the medium

category. Then, Zhang et al., [10] conducted another study related to the relationship of mathematical anxiety (MA) on mathematical performance. The result shows that middle school students in Asian countries have stronger negative mathematics anxiety than European students.

Independent learning is positively correlated with academic achievement in traditional higher education classroom settings for several samples [11]. It has a positive influence on students' learning outcomes in the algebraic structure course [7]. However, it is not denied that academic achievement, especially mathematics, in general, is low. Nevertheless, it is not an obstacle to always try to improve in terms of various components of mathematical knowledge including mathematical objects.

There are several components of mathematical knowledge as a part of direct mathematical objects such as the introduction of structure sense in algebra courses at the university level. Recognizing the structural sense of the set elements in the form of numbers is one of the obstacles in learning abstract algebra [12]. This is because the students do not master the basic, intermediate, and secondary mathematics that underlies the set [13]. Some structural components in university algebra are analogous components of high school algebra, so it is recommended to emphasize the structure sense of high school algebra [14].

The sensitivity of the mathematical structure [15] can lead to an intuitive ability to symbolic expressions, including skills to interpret, manipulate, manage, and perform symbols in different roles in learning algebra [16]. Low sensitivity to structure (structure sense) can also affect students' algebraic thinking abilities [17] and the ability to connect mathematical structures in algebra.

The structure that is described as a structure in a set and several types of set properties is a comparison of its properties, and a structure as all properties that are studied [18]. Besides, the structure of algebra is also a knowledge that informs the nature of solving equations, simplifying expressions, and multiplying polynomials [19].

Abstract algebra is the study and generalization of the structure of algebraic structures needed for algebraic reasoning [13]. Abstract algebra is also an essential part of the preparation of secondary and middle school teachers [20]. The core concepts in abstract algebra are binary operations and functions. The core concept in abstract algebra has a productive potential to connect to the middle school level. Binary functions and operations as initial concepts play essential roles in many abstract algebra topics [21].

The vital role of the concept is to connect the school mathematics, thus learning abstract algebra requires basic mathematics. This interest is intended

to help build connections in understanding abstract algebra. Some scholars have examined the relationship between school mathematics and abstract algebra [19][22][23][24][25][26]. Cook [27] further emphasizes in his dissertation hypothesis that the difficulties experienced by students in learning abstract algebra are due to the lack of an established connection between university mathematics and school mathematics.

Some connections are formed when students try to build formulas through procedures that lead to the acquisition of concepts in the unit (Evitts in [28]). Formulas, rules, and algorithms are used for completing any mathematical tasks [29]. Bass [24] provides an example of how ideas from abstract algebra and other fields of mathematics can be developed from and connected with school curriculum mathematics. Emphasizing mathematics connections and helping to understand the operation or nature of algebra are used to achieve coherence [15] thoroughly.

Building connections as mathematical processes or activities throughout mathematics, students must be involved in building activities or identifying the connections that are contained [18][30] are the aim of this study:

The purpose of this study is (1) to examine the extent to which the students' independent learning in abstract algebra through mentoring modules as a first step to overcoming students' difficulties can influence, simultaneously, with the ability to recognize a structure sense on the ability of mathematics connections, and (2) to assess the extent to which the students' habits of independent learning and the ability to recognize structure sense through weekly tasks, partially, affects the ability of mathematics connections.

While the formulation of the problems in this study is as follows:

- (1) Do the students' independent learning and the structure sense ability simultaneously affect the mathematics connections in abstract algebra material?
- (2) Do the students' independent learning and the structure sense ability partially affect the mathematics connections in abstract algebra material?
- (3) Which variable, independent learning or structure sense ability, is more dominant in influencing the mathematics connection?

II. RESEARCH METHOD

The method used in this study is quantitative, with one saturated sample group [31] of 26 students. This research was conducted for 7 weeks. The treatment was by giving the students a module to assist the students in independent learning activities. Every week, the students were given independent assignments that are already contained in the module. The assignment was submitted based on the

schedule, so there is no overlap with other students. The goal is that the lecturer can freely observe and ask a little about the tasks being done. Then after 7 weeks, a mathematics connection test and an independence questionnaire were given.

The research variables are two independent variables = x and one dependent variable = y . Independent learning is x_1 variable; the structure sense ability is x_2 variable, and mathematics connection is y variable. The series of statistical analyses were employed, such as assumption test, linearity test, multiple regression test, the partial test of multiple regressions, and determination test using the SPSS program (Sukestiyarno, 2016).

2.1. Research Instrument

The research instrument used was a questionnaire. It was used to measure independent learning with 38 questions (20 favourable questions and 18 unfavourable questions) using a Likert scale. The instrument to measure the ability of structure sense was using the questions in the module as a weekly task. The questions in the assignment were arranged based on indicators of ability to recognize the structure sense and are equipped with rubrics and indicator predictions on the questions about structure sense.

2.2. Instrument Trials

Meanwhile, to measure the ability of mathematics connections, test questions consisting of 3 item descriptions were used. All questions were validated by experts and tested on students who had taken abstract algebra. The results of the empirical validation of the two independent learning questionnaire instruments and mathematics connections with SPSS obtained high categories for the connection test questions by 0.846, and the reliability of the independent learning questionnaire was 0.677 with 'sufficient' categories and the validity of all valid items results varied between sufficient, high and very high. While the validity of the mathematics connection instrument, item 1 was 0.922, the category was very high, item 2 was 0.685, the category was quite high, and item 3 was 0.928, the category was quite high.

III. RESEARCH FINDINGS

The data were analyzed statistically, including assumption tests, linearity tests, simple regression tests, multiple regression tests, and multiple partial tests (Sukestiyarno, 2016). The assumption test shows that the normality test with the Kolmogorov Smirnov test shows the significance value $\text{sig} = 0.001 > 0.05$ which means the distribution of variables is normal. Furthermore, the decision is also strengthened in Figure 1, which shows the diagram

is not far from the normal diagonal line, and then the data is normally distributed. Overall, the data of the mathematics connection ability is normally distributed. So the assumptions are fulfilled.

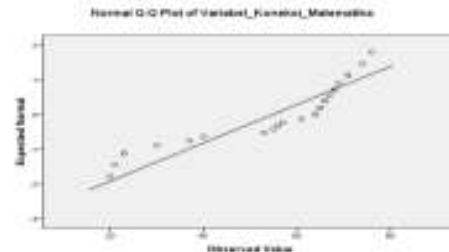


Figure 1 Plot of Q-Q Diagram

Furthermore, the homogeneity test results, based on Figure 2, show that because the value of kurtosis = -0.536, it shows a negative value, so the data tends to be blunt, but the value is not far from zero so it can be said to be homogeneous data. Next, by looking at all three quartile values, they indicate values that are not too wide. If it is seen from the box plot in Figure 2 and Figure 3, it does not show a significant slope and because the normality test has been met, it can be concluded that the assumption of homogeneity is met.

Statistics		
Mathematics Connection Variable		
N	Valid	28
	Missing	0
Mean		55.0000
Std. Error of Mean		3.56133
Skewness		.963
Std. Error of Skewness		.454
Kurtosis		-.536
Std. Error of Kurtosis		.887
Percentiles	25	39.2500
	50	64.0000
	75	68.0000

Figure 2 Output Statistic

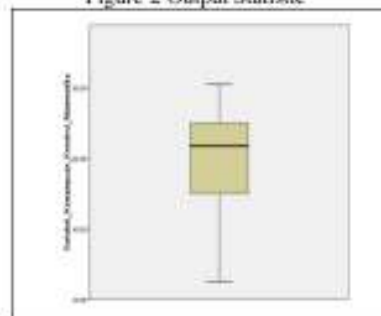


Figure 3 Homogeneity test results of mathematics connection ability

The linearity test through testing simple linear regression x_1 to y with the Model $Y = \beta_0 + \beta_1 X_1 + \varepsilon$ shows a linear equation or x_1 has a linear relationship with y . Similarly, testing simple linear regression x_2 to y with the Model $Y = \beta_0 + \beta_2 X_2 + \varepsilon$ shows a linear equation or x_2 has a linear relationship with y .

Because the assumption test and the linearity test are fulfilled, further tests, namely the multiple regression test and the multiple partial regression test, to examine the effect of the two independent variables on the dependent variable are presented in the following explanation.

3.1 Multiple Regression Test

Regression model: $y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \varepsilon$

- a) Forms of Linear Model Hypotheses:

$H_0: \beta = \begin{pmatrix} \beta_1 \\ \beta_2 \end{pmatrix} = 0$ (the equation is non-linear or there is no relation between x_1, x_2 and y)

$H_1: \beta = \begin{pmatrix} \beta_1 \\ \beta_2 \end{pmatrix} \neq 0$ (the equation is linear or there is a relation between x_1, x_2 and y)

- b) The analysis design formulation: the multiple linear model estimator is $\hat{y} = a + b x_1 + c x_2$ with a two-party test and a significance level of 5%. The regression equation based on the sample can be seen in table 1. It was obtained values $a = -56,313, b = 1,024$ and $c = 0,807$, so the regression equation is $\hat{y} = -56,313 + 1,024 x_1 + 0,807 x_2$
- c) Testing the values of $a, b,$ and c by accepting or rejecting the hypothesis can be seen in table 2. It was obtained value $F = 30,006, sig = 0,000$. Because the value of $sig = 0,000 < 0,05$ then H_0 is rejected and H_1 is accepted. So, the equation is linear or x_1 and x_2 simultaneously have a linear relationship to y or simultaneously have a positive effect on y .
- d) Analysis of the coefficient of determination R^2 can be seen in table 3. The summary obtained value $R^2 = 0,723 = 72,3\%$. This value indicates that the independent learning variable can explain the variation of the mathematics connection variable y x_1 and the sense structure variable x_2 simultaneously by 72.3%. In other words, x_1 and x_2 simultaneously affect the mathematics connection variable y by 72.3%, and there are still 27.7% of the y variable that is influenced by other variables.

Table 1. Output Coefficients

Model		Standardized		t	Sig.
		B	Error		
1	(Constant)	-56.313	17.285	-3.258	.003
	Independent Learning Variable	1.024	.460	2.227	.036
	Structure Sense Variable	.807	.271	2.976	.007

Table 2. Output ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	5959.847	2	2979.924	30.006	.000 ^a
	Residual	2284.153	23	99.311		
	Total	8244.000	25			

Table 3. Output Model Summary

Model	R	R Square	Adjusted R Square	Sd. Error of the Estimate
1	.850 ^a	.723	.699	9.96549

3.2 Partial Test of Multiple Regressions

Form of the hypothesis proposed:

H_0 : Regression coefficient is not significant (there is no effect)

H_1 : Regression coefficient is significant (there is an effect)

The results of the analysis can be seen in table 1, on the sig value of the t distribution. It was obtained the independent learning variable $sig = 0,036 < 0,05$, so H_0 is rejected, and H_1 is accepted, meaning that independent learning affects the variable of mathematics connections. Whereas for structure sense variables, the value of $sig = 0,007 < 0,05$ so H_0 is rejected and H_1 is accepted, meaning that the structure sense variable influences the mathematics connection variable.

At last, the regression test, in this case, can be concluded that both partial and multiple regressions of x_1 and x_2 simultaneously affect the y variable.

3.3 Investigation of Dominant Influence Factors

The x_1 variable influences y variable by 61.3%, after involving the x_2 variable is only able to increase R^2 by $72.3\% - 61.3\% = 11\%$. On the other hand, the x_2 variable affects y variable by 66.3%, by involving the x_1 variable, it can increase the value of R^2 by $84.9\% - 66.3\% = 18.6\%$. So the x_1 variable gives more dominant contribution to the y variable.

3.4 Multicollinearity, Autocorrelation, & Heteroscedasticity Checks

Table 4. Output Coefficients

Model		Collinearity Statistics	
		Tolerance	VIF
1	Independent Learning Variable	.401	2.493
	Sense Structure Variable	.401	2.493

From table 5 below, it can be seen that the value of tolerance and VIF are far from 1, so, it can be concluded that there is multicollinearity disturbance. Then, the table also shows that the correlation between independent learning and structure sense is above 0.5, i.e., -0.774. This shows a high degree of correlation. It means that there is an intersection of indicators between independent learning and structure sense.

Table 5 Output Coefficient Correlations

Model			Structure Sense Variable	Independent Learning Variable
1	Correlations	Structure Sense Variable	1.000	-.774
		Independent Learning Variable	-.774	1.000
	Covariances	Structure Sense Variable	.074	-.096
		Independent Learning Variable	-.096	.211

To check the autocorrelation, the Durbin-Watson value can be seen from table 6 below. It shows the value of 1.419. This value is in the interval $-2 < DW < 2$, meaning that it is in an area that there is no autocorrelation. It means that the assumption of each observation measurement from one observation to the next is to meet the requirements to have a

homogeneous variant.

Table 6 Output Model Summary

Model	R	R Square	Adjusted Std. Error	
			R Square	Estimate
1	.850	.723	.699	9.96549

For heteroscedasticity checks, it can be seen in the scatter plot diagram between the errors that occur (the difference between the prediction of the dependent variable with the dependent variable observational data): it appears that the points that occur are entirely spread around the zero lines, some are above the zero lines and there are which is below the zero line. In this case, it does not form a specific pattern. So the assumption that the variant error is identical is fulfilled.

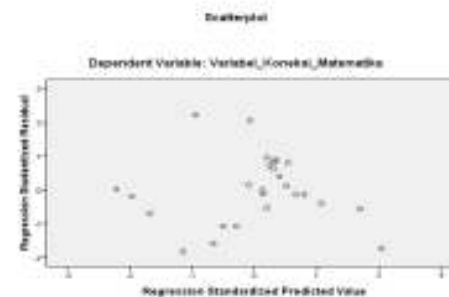


Figure 3 Plot Diagram

The general conclusion of simple regression analysis and multiple regression analysis dealing with the effect of independent learning and understanding of structure sense in abstract algebra caused by mentoring process of using structure sense-based modules affect the achievement of mathematics connection ability.

Table 7. Output Residuals Statistics

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	20.8066	86.3867	55.0000	15.44001	26
Std. Predicted Value	-2.215	2.033	.000	1.000	26
Standard Error of Predicted Value	1.993	5.134	3.248	.974	26
Adjusted Predicted Value	20.7455	90.4157	55.1751	15.66519	26
Residual	-17.28585	20.64243	.00000	9.55856	26
Std. Residual	-1.735	2.071	.000	.959	26
Std. Residual	-1.829	2.218	-.008	1.016	26
Deleted Residual	-19.41575	23.66117	-.17509	10.74445	26
Std. Deleted Residual	-1.935	2.446	-.003	1.066	26
Mahat. Distance	.038	5.674	1.923	1.718	26
Cook's Distance	.000	.263	.042	.070	26
Centered Leverage Value	.002	.227	.077	.069	26

To sum up, it turns out that the dependent variable tends to be normally distributed and homogeneous. This shows that the mentoring strategy through a structure sense-based module can raise students' independent learning in building mathematics connection skills that are almost equal to the mean of 55,0000 (see table 7). Based on the test, it shows that the independent learning variable has a dominant effect compared to the structure sense variable on the mathematics connection ability variable. It means that the variation in students' mathematics connection ability is explained more by the independent learning variable than the structure sense variable. Thus, in order to achieve high mathematics connection abilities, students should, first, have high independent learning, and then develop the ability to recognize structure sense.

IV. CONCLUSIONS

Based on the analysis of statistical test data, the following conclusions are obtained.

- 1) There is an influence of students' independent learning and the ability to recognize a structure sense simultaneously on the ability of mathematics connections in abstract algebra material;
- 2) There is an influence of students' independent learning and the ability to partially recognize structure sense on the ability of mathematics connections in abstract algebra material; and
- 3) The more dominant variable that influences the mathematics connection is independent learning compared to structure sense.

To sum up, it turns out that the dependent variable tends to be normally distributed and homogeneous. This shows that the mentoring strategy through a structure sense-based module can raise students' independent learning in building mathematics connection skills that are almost equal to the mean of 55,00 (see table 7). Based on the test, it shows that the independent learning variable has a dominant effect compared to the structure sense variable on the mathematics connection ability variable. It means that the variation in students' mathematics connection ability is explained more by the independent learning variable than the structure sense variable. Thus, in order to achieve high mathematics connection abilities, students should, first, have high independent learning, and then develop the ability to recognize structure sense.

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EXCLUDE BIBLIOGRAPHY ON

EXCLUDE MATCHES < 3%