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Fragmentation of thinking structures and learning independence in solving differential equation problems

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Abstract: This study aims to describe the characteristics of fragmentation of students' thinking structures in constructing exponential equation material in terms of learning independence. The form of research used in this study is a mix-method study, where quantitative data is supported by descriptive qualitative data. Quantitative data collection in this study used an independence questionnaire test. The magnitude of the influence of learning independence and fragmentation of thinking can be seen from the R square value which shows 0.857 or 85.7%. While 14.3% is influenced by other variables that were not studied. In addition, from 48 questionnaire items with a sample of 40 students, the average results of students in each category were obtained, including those with high learning independence of 32.5%, moderate learning independence of 55%, and 12.5% in the low category of learning independence. The study is supported by qualitative data with the think aloud method and interviews. The forms of fragmentation of thinking structures that may occur include: Hole construction, pseudo construction, random structure and separate structure. The subjects in this study were 40 students taken using the purposive sampling method. Subjects To ensure the validity of the data, this study used the triangulation method to determine the suitability between the data from the think aloud method and those reinforced by the data from the interview method. The results of this study indicate that subjects with students with independent learning experience a form of fragmentation of the thinking structure including: construction holes, pseudo-constructions, random structures and separate structures. The characteristics of students with an independent learning style who experience fragmentation are: 1) construction holes are seen when students do not have an understanding of the concept of homogeneous differential equations, 2) Pseudo-constructions are seen when students experience fuzzy memory events, where the subject seems to remember the concept that has been learned but it turns out that the concept is not quite right, 3) Random structures occur when students ignore the requirements that must be met to become a form of equation that must be transformed integrally from homogeneous differential problems and 4) Separate structures occur when students cannot connect the knowledge they have to solve problems that have never been exemplified by the lecturer. The impact of the form of fragmentation experienced by students causes students to have difficulty in solving mathematical problems because the knowledge they have is only limited to memory.

INTRODUCTION

Thinking Structure Thinking according [1]is making decisions or considering something using reason by considering the memory that is owned. The structure of thinking reviewed from the psychological aspect related to efforts to develop IQ or thinking ability is known as cognitive structure. The structure of thinking is formed from the process of thinking that involves the individual's cognitive structure (scheme), where the cognitive structure works together with other related ideas at the same time [2]. According [3], the structure of thinking is an arrangement of cognitive structures in the form of symbols, specific facts, general facts that are interconnected and formed from the process of reducing important information to make decisions. Meanwhile, according [4] the structure of thinking is a representation of the process of thinking in the form of a flow in solving problems carried out by someone in solving a problem. [5] the structure of thinking is a process of thinking that involves the process of assimilation and accommodation, in the process of assimilation new stimuli will be integrated with existing schemes

(already formed) then accommodation is the process of adjusting new stimuli to form new schemas or modify (change) old schemas. In this study, the structure of thinking is defined as a structure formed from the results of the thinking process when constructing concepts or solving problems that involve individual cognitive structures (schemes) and are interconnected because of the process of assimilation and accommodation so as to form a flow to solve problems. Well-formed knowledge construction makes it easy for students to find how to solve the problems given. Therefore, learning must be designed in such a way as to involve active students in learning. Students are directed to find their own knowledge. That way, the knowledge received by students will be stored well in their memories. The results will be different if learning is carried out using traditional learning methods with teachers lecturing about the material being taught. Students are only required to memorize existing theories without students knowing how the theory exists. The teacher-centered learning process results in students being less creative in solving problems because they are fixated on the theories or methods taught by their teachers. Learning by rote will also make students forget easily.

[6] explains that fragmentation of thinking structures is a phenomenon of inefficient information storage in the brain that disrupts the process of constructing concepts and solving mathematical problems. The disruption of the process of recalling information is caused by the absence of integration of new stimuli into the old scheme so that the arrangement of schemes or cognitive structures that do not match the scientific structure or the actual cognitive structure, resulting in the construction of incomplete structures, pseudo structures, separate structures or random structures. When the new stimulus is not appropriate, the accommodation process will be reconstructed so that the new structure can be integrated with the previous structure [7]. The reconstruction process when accommodation is running often does not always go well without help from other people or teachers. This accommodation process plays an important role in forming students' thinking structures. Efforts are needed to oversee the accommodation process by teachers so that the process runs correctly so that the construction of knowledge possessed by students is correct. Fragmentation of thinking structure in this study is defined as the disruption of the information recall process caused by an inappropriate problem-solving flow because the schema (thinking structure) that is formed cannot be integrated with the stimulus given, thus inhibiting the decision-making process to solve the problem. The inconsistency of the structure (scheme) can be in the form of an incomplete structure (scheme), a pseudo structure, a separate structure, or a random structure [6].

Self-regulated learning (SLR) is an important aspect that greatly determines the success of learning. Agree with [8] stated that student learning independence is now a key factor in achieving educational success, so it is important to get serious attention from policy makers and academics. According to Zimmerman & Schunk [8] SRL describes a continuously evolving process, in which learners independently activate and maintain their cognitive functions, feelings, and behaviors with the aim of achieving personal learning goals. Meanwhile, [9] Learning independence is a mechanism that allows students to manage their potential, actions, and emotions for success in undergoing a directed learning process. In addition, [10] stated that self-regulated learning is an effective form of learning where students themselves design goals, make plans before starting to learn, monitor and organize their knowledge, motivate themselves during the learning process, and reflect on their learning outcomes.

According to Lowry in [11] Self-regulated learning is defined as a process where individuals take the initiative to learn with or without the help of others, diagnose their own learning needs, formulate learning goals, identify learning resources that can be used, choose learning strategies, and evaluate their learning outcomes. Students show good self-regulation if they can master various learning strategies and have the skills to determine their use appropriately based on the situation [12].

Based on several opinions above, it can be concluded that learning independence is an effort made by students with full awareness to set goals, organize learning approaches, manage motivation, supervise themselves during the learning process, and assess their learning achievements. Various definitions related to learning independence have been expressed by several figures, where each has the same meaning. Learning independence consists of several aspects, characteristics and components found in students. [12] argues that learning independence has five basic characteristics as follows: 1) they have knowledge; meaning they are equipped with sufficient knowledge about themselves, the environment, learning strategies and appropriate task content. 2) they use knowledge; meaning they use knowledge for problem solving and achievement. 3) they are self-motivated which means that they have sufficient intrinsic motivation to make activities. 4) they have critical thinking that always concentrates on their

learning experiences. 5) they have a sense of responsibility which means that they direct their own learning process and consider themselves committed to this problem.

In general, [13] explains that self-regulated learning consists of three main aspects in learning, namely: 1) Metacognition in SRL is the ability of students to plan, set goals, organize, monitor themselves, and evaluate themselves on various sides during the acceptance process. This process allows them to be self-aware, know a lot and determine the approach in learning. 2) Motivation in SRL is where students feel high self-efficacy, self-attribution and are interested in intrinsic tasks. From a motivational perspective, independent individuals are aware of their competence, pay attention to high self-confidence. Individuals who have high motivation, start learning by showing extraordinary efforts and perseverance during learning. 3) Behavior in SRL is the student's effort to choose, structure, and create an environment that optimizes learning. They seek advice, information and places where they feel most comfortable to learn.

METHOD

The form of research used in the mix method research, where quantitative data is supported by descriptive qualitative data. Quantitative data collection in this study used an independence questionnaire test to test the regression on the magnitude of the influence of learning independence and fragmentation of thinking. The research is supported by qualitative data with the think aloud method and interviews. The forms of fragmentation of the thinking structure that may occur include: Hole construction, pseudo construction, random structure and separate structure. The research was conducted on civil engineering students of Sultan Agung Islamic University in calculus class 3, with diverse characteristics of 3rd semester students, so that learning independence is different. The subjects of this study were determined using the Purposive Sampling technique, where the subjects of the study were selected based on considerations of learning independence. Based on several opinions that have been described, the aspects and indicators used in this study are the division of student learning independence criteria into three categories, namely high, medium, and low with the following criteria:

High learning independence : $X > \overline{X} + \frac{1}{2}s$
Medium learning independence : $\overline{X} - \frac{1}{2}s \leq X \leq \overline{X} + \frac{1}{2}s$
Low learning independence : $X < \overline{X} - \frac{1}{2}s$
Note:
$\overline{X}$: average learning independence score
X : learning independence score
S : standard deviation of learning independence score

TABLE 1. Indicators of student learning independence

Aspects	Indicator
Metacognition	Planning learning style
	Setting learning goals
	Self-regulating learning needs
	Self-monitoring learning progress
	Self-evaluating learning outcomes
Motivation	Conducting assessments of abilities, competencies and strengths that one has
	Using abilities, competencies and strengths that one has in learning
Behavior	Choosing a learning process environment to be more optimal
	Structuring a learning process environment to be more optimal

RESULTS AND DISCUSSION

Then to answer the next problem, namely whether or not there is an influence of learning independence on the fragmentation of students' thinking structures. To find out the results, a regression test was carried out using data from the questionnaire results and the results of the student's work test. The results obtained are as follows.

TABLE 2. Significance Results of Regression Test

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	3874.039	1	3874.039	226.853	.000[b]
	Residual	648.936	38	17.077		
	Total	4522.975	39			

Dependent Variable: Fragmentation
Predictors: (Constant), learning independence

It is known that the ANOVA results obtained a significance value of 0.000 <0.05 with the Ho criterion rejected, which means that there is a positive influence of learning independence on the fragmentation of students' thinking structures. This can also be proven through a comparison of the r table and r count values in the following table.

TABLE 3. Results of t Count Regression Test

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	32.869	2.681		12.262	.000
	Kemandirian	.226	.015	.925	15.062	.000

Dependent Variable: Fragmentation
Predictors: (Constant), learning independence

The output results above obtained a t count of 15.062 and based on the data, the t table value is 2.024, so that t count> t table. In this case, it means that there is an influence as explained in table 2. How big the influence is can be seen in table 3.

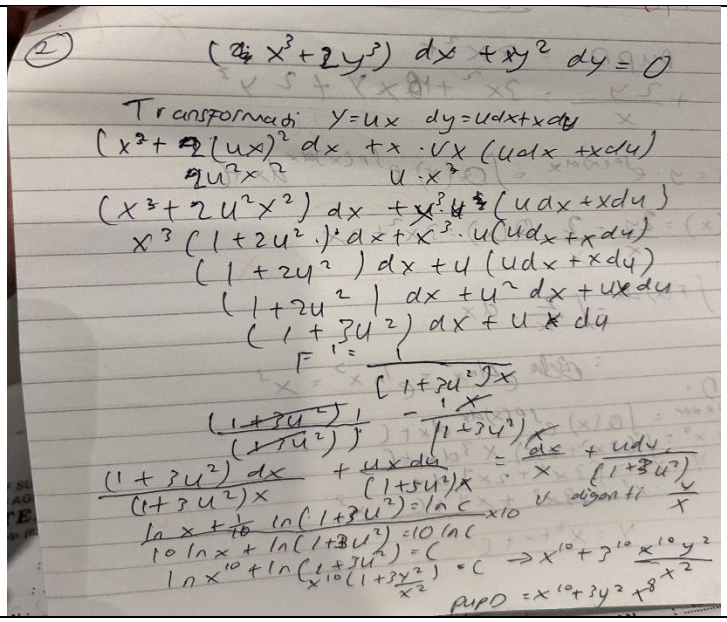
TABLE 3. Results of R Square Regression Test

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.925	.857	.853	4.132

a. Predictors: (Constant), learning independence

The magnitude of the influence of learning independence can be seen from the R square value which shows 0.857 or 85.7%. While 14.3% is influenced by other variables that were not studied. In addition, from 48 questionnaire items with a sample of 40 students, the average results of students in each category were obtained, including those with high learning independence of 32.5%, moderate learning independence of 55%, and 12.5% in the low category of learning independence.



The students' solutions with low independence are frequent in almost all aspects, namely construction holes when students do not have an understanding of the concept, random construction is wrong in the solution process for multiplying derivatives, and separate construction subjects cannot equate the solution process that has been exemplified by the previous lecturer.

FIGURE 1. Low independence

In students with low independence, the construction hole is seen when students do not have an understanding of the concept of questions that use exponents 3 while in the solution process it is written as exponents 2. So that the construction of thinking of students with low independence has been from the early stages. It was also found that low independence enters the random construction of the solution process to multiply the derivatives of the values of U and dy, so that $xy^2\ dy$ should be transformed into $x(ux)^2\ (u\ dx + x\ du)$ then if multiplied $u^2x^3\ (u\ dx + x\ du) = u^3x^3\ dx + u^2x^4\ du$. In students with low independence, a separate construction was also found where students could not equate the solution process that had been exemplified by the previous lecturer.

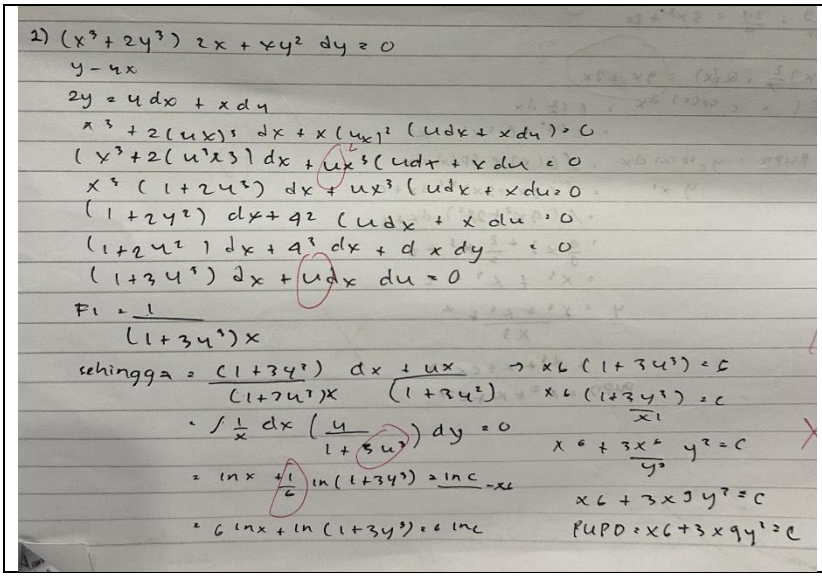
	Student completion with moderate independence is only seen in the aspect of pseudo-construction, students cannot present what they have written, random construction ignores the requirements that must be met.

FIGURE 2. Moderate independence

In students with moderate independence, it can be seen that the pseudo-construction of students experiences fuzzy memory events, where the subject seems to remember the concept that has been learned but it turns out that the concept is not quite right, seen when students can determine the correct process but there are stages that are not quite right $(ux)^2$ which should be u^2x^2 is instead only written as ux^2. Random construction ignores the requirements that must be met, for example from the integration $\frac{u}{1+3y^3}\,dy$ should be $\frac{1}{9}ln(1+3y^3)$ but instead at $\frac{1}{6}ln(1+3y^3)$. So that the construction of thinking of students with moderate independence experiences fragmentation of thinking pseudo-construction and random construction.

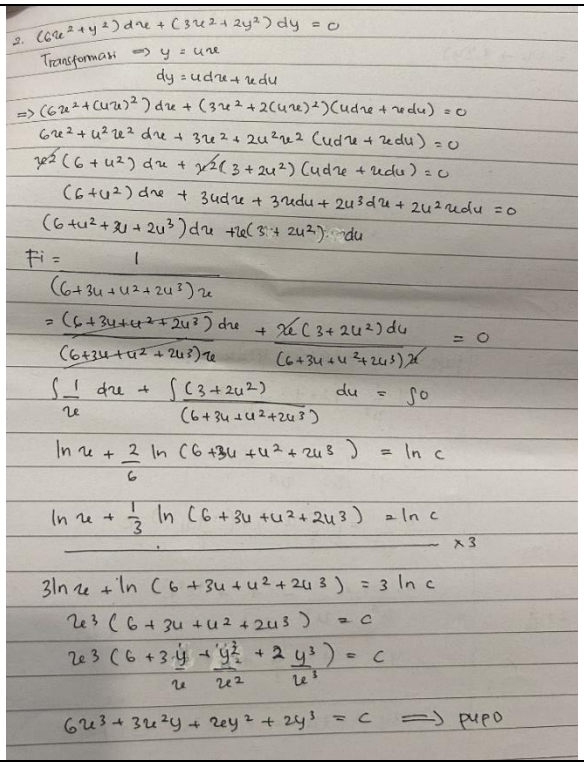
	The completion of students with high independence in their fragmentation did not appear to have any problems in the completion process.

FIGURE 3. High independence

In students with high independence, it can be seen that the fragmentation of their thinking is in accordance with the process of the results of the work and the results of the interviews that have been conducted. In students with high independence, it is good and correct.

CONCLUSION

Based on the results of the study and discussion of the influence of fragmentation of students' thinking on learning independence, it was concluded that 1) qualitative data shows a significant influence between fragmentation of students' thinking and learning independence with the results of linear regression can be seen from the R square value which shows 0.857 or 85.7%. While 14.3% is influenced by other variables that are not studied. 2) In addition, there is an influence of learning independence and fragmentation of thinking on each indicator (high independence, medium independence, low independence) from 48 questionnaire items with a sample of 40 students, the average results of students in each category are obtained, including those who have high learning independence of 32.5%, medium learning independence of 55%, and 12.5% in the low category of learning independence.

The results of observations and interviews of research subjects on the relationship between fragmentation of students' thinking and learning independence are reviewed. Subjects with high independence of fragmentation of thinking do not appear to have any problems in the resolution process. Moderate independence of thinking frequency is seen only in aspects, namely pseudo-construction of students who cannot present what they have written, random construction ignores the requirements that must be met. Low independence of thinking frequency is seen in almost all aspects, namely construction holes when students do not have an understanding of the concept, random construction is wrong in the process of solving to multiply derivatives, and separate construction of subjects who cannot equate the solution process that has been exemplified by the previous lecturer.

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