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# RESTRUCTURING OF STUDENTS' THINKING IN JUNIOR HIGH SCHOOL THROUGH DEFRAGMENTATION FOR SOLVING MATHEMATICAL PROBLEMS

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**ABSTRACT**

Problem-solving in math is still a problem today. Studies show that students still make mistakes in answering math problems. Errors in answering the questions indicate that there is fragmentation in the thinking structure of students. This article uses a systematic review method. Researchers selected articles according to the criteria and found 9 articles with a total of 25 research subjects. Data collection was carried out in two main stages, namely the search and selection stages. The results show that students experience many obstacles at the stage of re-checking the integrity of the completion steps because of the habit of students who skip the re-examination and are sure that the answer is correct. A common type of error in the construction of a mathematical concept is a construction hole. Construction holes can be overcome by the emergence of schemes to complement the imperfections of students' thinking structures in solving mathematical problems. The type of defragmentation that is most often given is scaffolding. Scaffolding is considered the most effective for all types of mistakes made because it can be done and later reduced so that students can solve math problems independently.

**Key Words**: defragmenting; students' thinking; solving mathematical problem

## INTRODUCTION

Having the ability to solve problems is essential for students (Siregar, 2017). As a result, students will understand how to complete each step of a problem when given one. NCTM composes that there are five standard learning processes, one of which is the ability to solve problems (National Council of Mathematic Teachers, 2000). Thus, after presenting material, the teacher will give a specific task to solve to improve students' skill at problem-solving, in particular mathematics.

Even so, the ability to solve mathematical problems continues to pose a problem. This is indicated by the number of studies that state that students still make mistakes when they solve math problems. One of the reasons is that the mathematical problem created is not based on the indicators of problem-solving abilities (Wijaya et al., 2021). In addition, errors can also be made because students are accustomed to questions that require only one answer (Gunawati et al., 2015). Another cause is that students cannot analyze problems well and are unable to relate problems to other concepts (Biber et al., 2013; Gal & Linchevski, 2010). These causes indicate that there is fragmentation or errors in the structure of students' thinking in solving mathematical problems.

According to Piaget, the structure of thinking is a collection of schemas or cognitive structures that exist in the brain (Ribaupierre, 2015). Piaget also explained that if someone is asked a question, then he will undergo a process of adaptation to the cognitive structure. The process of adapting to this cognitive structure is called the thinking structure (Sudbery & Whittaker, 2018).

When someone solves a problem, his thinking structure will be active in order to solve it. As a result, when there are errors that arise during the problem-solving process, it is caused by fragmentation in the structure of thinking (Subanji, 2015).

The term "fragmentation" was adopted from the term inefficient storage of data on computers. This condition occurs because the data placed on the storage media are not organized sequentially (Usodo et al., 2020). The analogy of the term "fragmentation" in the structure of thinking is a phenomenon of information storage's low efficiency in the brain which hinders the process of reconstruction and solving mathematical problems (Wibawa et al., 2017). Fragmentation in the structure of thinking often occurs because of meaningless learning, emphasis on memorizing formulas, and how to carry out completion steps (Subanji, 2015).

On computer systems, fragmentation can be repaired through the defragmentation process. The stages that occur in the defragmentation process are inspection, repair, and re-checking (Wibawa et al., 2018a). This also applies to the learning process. In the learning process, students can regulate the structure of their thinking through the application of interventions to solve the problems given (Hidayanto et al., 2017). The implementation of this intervention will probably help students improve their inappropriate thinking structures. The improvement process through intervention is called the defragmentation of the thinking structure.

Defragmentation of students' thinking structures can be executed by disequilibration cognitive conflict, or scaffolding (Kumalasari et al., 2016). Fragmentation can be corrected by highlighting the calibration, such as asking several questions that can cause students to hesitate or rethink the answer, so that students can reflect on the answers given, such as: "Are you sure about the answer?", "Why is the formula like that?", etc. In addition, giving cognitive conflict can also be conducted by providing new statements that differ from what students think or their previous knowledge. Not only that, defragmentation using scaffolding can be done by providing encouragement, motivation, questions, guidance, pictures, or learning aids.

Based on the steps of solving the Polya stages, students' thinking structures were analyzed to figure out how to defragment them and work toward solving mathematical problems. Cognitive maps function as visual maps that describe various ways to interpret a concept based on its propositions (Gunawati et al., 2015). The map is analyzed based on the Polya stages, namely: (1) understanding the problem, (2) preparing a settlement plan, (3) executing a settlement plan, and (4) re-examining the integrity of the steps of completion taken (Efendi & Pratama, 2020).

Cognitive mapping will be helpful in defragmenting. Through the map, students may be able to figure out the mistakes that have been made while constructing mathematical concepts. The errors consist of pseudo thinking, connection holes, construction holes, analogous and logical thinking errors (Subanji, 2015; Subanji & Nusantara, 2013). Based on this, there are several types of defragmentation processes in terms of errors in constructing mathematical concepts, including schema appearance, knitting schemes, repairing analogical, and logical thinking errors (Subanji, 2015).

Studies have been undertaken to establish if defragmentation improves the thinking structure of students from secondary to tertiary levels (Hanifah, 2018; Kirnasari, 2016; Nazihah, 2018). These studies demonstrate that defragmentation can be applied to fix the inappropriate thinking structure in solving mathematics. Not only that, the research conducted has covered various categories of subjects, which means that not only subjects with normal abilities were studied, such as

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impulsive and reflective (Septian et al., 2018; Wibawa et al., 2018b). The mathematical material tested is not limited to algebra, but has expanded to geometry, function limits, exponents, logic, and so on (Nazihah, 2018; Rochayati & Fa'ani, 2019; Wibawa et al., 2013; Wulandari et al., 2020). Accordingly, the study will review various studies in order to discover more detailed information about defragmentation in order for teachers to easily implement it to students.

In the introduction, the researchers outlined several writing objectives for this systematic study, including the following:

1. Understanding the obstacles experienced by students when solving problems according to the Polya stages.
2. Understanding the types of mathematical concept construction errors that are typically experienced by students.
3. Understanding the process of defragmentation that occurs frequently in students.
4. Types of defragmentation are used in restructuring students' thinking

## RESEARCH METHOD

The method employed in this article is a qualitative systematic review. It is different from a literature review or literature study. A summary of the results in this method is achieved by using a scientific approach and a research protocol. In addition, the search for results and articles is carried out systematically and there are certain criteria that must be fulfilled. The systematic study method used is based on the opinion of Dwan, Gamble, Williamson, & Kirkham (2013).

Data collection took place in two phases, namely the search phase and the article selection phase. The following are the criteria for the articles to be selected.

1. Selected articles related to mathematical disciplines.
2. Various field research results.
3. The education level of the selected research subjects comes from junior high school or its equivalent.

As many as 1580 research results were found in online databases. By selecting only articles and eliminating duplicate ones across different databases, the researcher found 26 articles. In accordance with the three specified criteria, 11 articles are suitable. Furthermore, the article is sorted again by reading the entire contents. Using this stage, we filter 9 articles that meet the requirements for a systematic review. These nine articles contain 25 research subjects with results before and after defragmentation. Figure 1 shows a graph of the search and selection of articles.

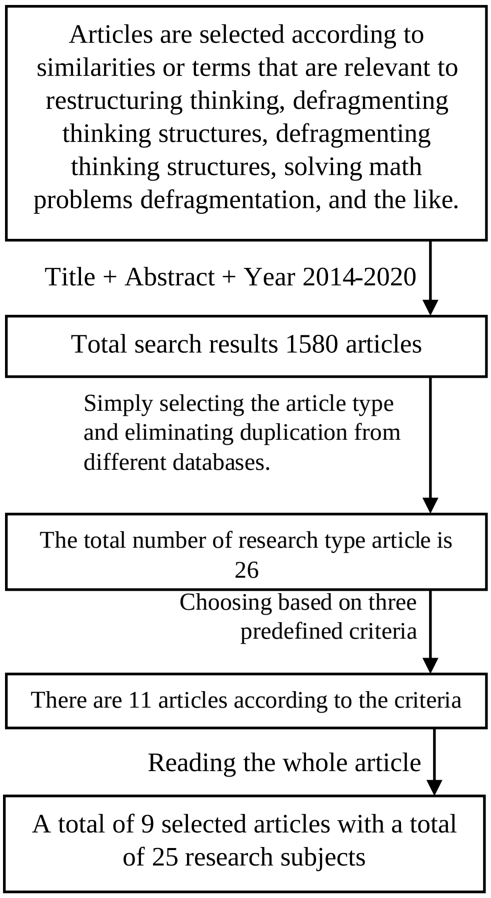


**Figure 1. Article Search and Selection Flow**

## FINDING AND DISCUSSION

Listed below are the research titles and articles used in this study.

**Table 1. The Data of Selected Article for Review**

| No | Name (Year) | Title |
|---|---|---|
| 1 | Salman Sakif, Subanji, Sisworo (2014) | Defragmenting of Thinking Process Through Cognitive Mapping to Fix Student's Error in Solving |
| 2 | Erna Gunawati, Toto Nusantara, Abd. Qohar (2015) | Defragmenting Thinking Structures through Cognitive Mapping to Correct Students' Errors in Solving Story Problems on Block Materials |
| 3 | Taufiq Hidayanto, Subanji, Erry Hidayanto (2017) | Description of Thinking Structure Errors in Junior High School Students in Solving Geometry Problems and Their Defragmenting: A Case Study |
| 4 | Ayu Ismi Hanifah (2018) | Defragmenting Junior High School Students' Husk Knitting in Solving Algebraic Problems |
| 5 | Muhammad Ali Bahrudin, Nonik Indrawatining-sih, Zuhrotun Nazihah (2019) | Defragmenting the Thinking Structure of Junior High School Students in Solving the Flat Shape Problem |
| 6 | Puspita Ayu Damayanti, Subanji, Sukoriyanto (2020) | Defragmenting of Student's Impulsive Thinking Structures in Solving Geometry Problems |
| 7 | Junaidi Fery Efendi, Ryan Angga Pratama (2020) | Defragmenting Students' Pseudo Thinking Process in Solving Math Problems |
| 8 | Achmad Muhtadin (2020) | Defragmenting Thinking Structures Through Reflection to Correct Students' Mistakes in Solving Story Problems |
| 9 | Siti Aisya, Kusaeri, Sutini (2019) | Restructuring Students' Thinking through the Appearance of Schemes in Solving National Exam Questions for Mathematics Subjects |

Figure 2 illustrates the results of the research that were found in various selected articles according to the formulation of the problem.

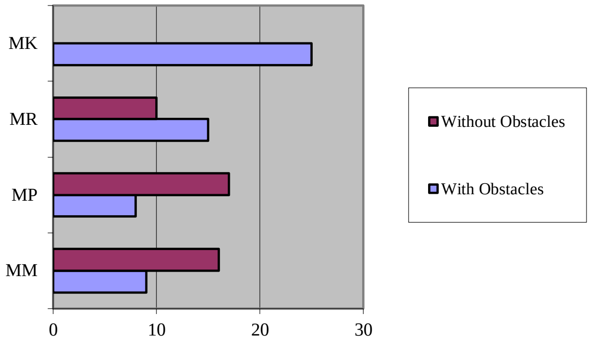


**Figure 2. Constraints according to Polya's Stages**

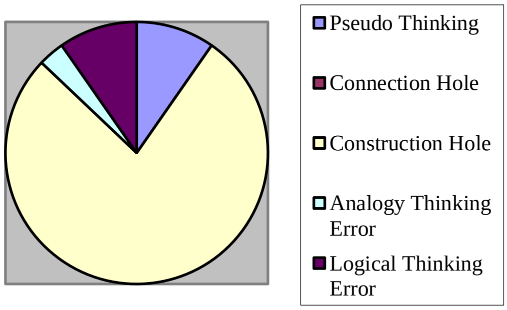


**Figure 3. Types of Construction Errors**

Based on Figure 3, the researchers found that the most frequent challenges students encountered occurred at the stage of reexamining the integrity of the completion, which involved as many as 25 research subjects. Not only in the final stage at the Polya steps, but students also experienced many obstacles in various other steps. The second stage that is most constrained by students is planning the completion steps of 17 of 25 subjects. Students also experienced problems at the stage of understanding the problems experienced by 16 subjects. Meanwhile, not many students had problems at the stage of carrying out the completion plan with a total of 10 subjects.

Seventy-seven percent of the subjects struggled with construction holes, the most common form of mathematical concept construction error. Other types of errors that are also experienced by many students are logical thinking errors and

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pseudo-thinking which both acquire 10% of 100% of the existing subjects. Another type of error that was observed but not significantly was analogical thinking, which accounted for about 3% of the whole. In contrast, junior high school students did not make many mistakes when they were constructing mathematical concepts in the form of connection holes since none of the subjects reported experiencing it.

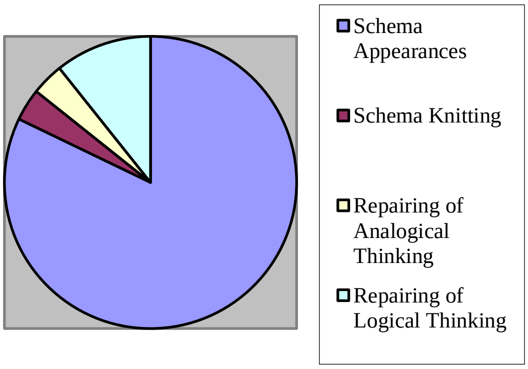


**Figure 4. Types of Defragmentation Processes that Occur**

Based on Figure 4, all kinds of defragmentation processes occur in students during the restructuring of thinking. Although not all students experienced these four types, the subject certainly experienced at least one process of defragmentation. The defragmentation process that occurred the most during the repair was schema appearances with a gain of 82% from 100%. The second process that also happens to many students is logical thinking error correction with an 11% gain. Finally, repairing of analogical thinking also occurred in 4% of students and another 3% experienced the process of schema knitting.

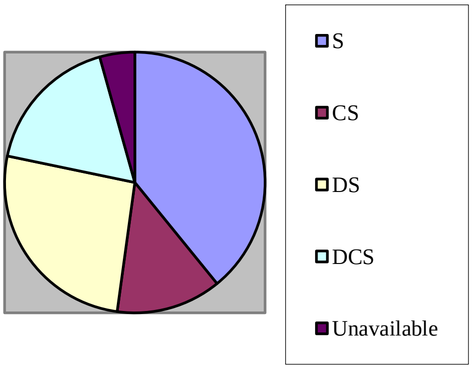


**Figure 5. Types of Defragmentation Utilized**

Note:
S : *Scaffolding*
CS : *Conflict Cognitive* dan *Scaffolding*
DS : *Disequilibrium* dan *Scaffolding*
DCS : *Disequilibrium*, *Conflict Cognitive*, dan *Scaffolding*

Based on Figure 5, the researcher found that the most common type of defragmentation was scaffolding because it was given to 41% of the existing subjects. The most widely used scaffolding is of the verbal type, in the form of encouragement, guidance, questions, or any remarks given by researchers or teachers without any tools, namely as many as 24 of the 25 subjects in the selected articles.

Scaffolding can be combined with other types of defragmentation. This was found to be more often combined with disequilibrium as much as 27% from 100%. Another combination is also done with cognitive conflict (cognitive conflict) as much as 14%. Not only that, scaffolding can also be combined directly with the two previous types of defragmentation which were also found in 14% of 100%. Even so, there were also 4% of subjects who did not get any kind of defragmentation.

Problem-solving in mathematics is mostly done based on the theory of Polya problem-solving stages. Every stage provides certain obstacles for each student. However, most of the students encountered problems in solving problems at the stage of re-examining the completion steps conducted. Students often ignore this step because they are sure the answer is already correct and are used to solving the question without checking the possibility of another answer (Gunawati et al., 2015). This does not only apply to the defragmentation of concept construction errors but also applies to all mathematical problem solving (Abidin, 2014; Triutami et al., 2016).

Due to the constraints that the students encountered, they make mistakes in constructing mathematical concepts when solving problems. A common mistake that occurred is the construction hole.

Construction holes occur due to incompleteness or imperfection of concepts formed in the structure of thinking in solving mathematical problems (Subanji, 2015). This incompleteness is resulting in difficulty for students to answer questions. This can occur due to the inability of students to remember previous mathematical concepts or skip them because they are considered unimportant when solving problems (Sholekah et al., 2017).

By determining the given defragmentation process we can remediate thinking structure errors. Every student is graded according to how many mathematical concept construction errors they have made. The most commonly chosen process is schema appearances. Schematic appearance is done to bring up a concept that is missing or not formed, causing incomplete thinking structures or construction holes (Subanji, 2015). Concepts will be raised so that students can solve the problems given.

Schema appearance can be done in various ways, including Disequilibrium, Conflict Cognitive, and Scaffolding (Kumalasari et al., 2016). Not only that, all defragmentation processes can occur with the help of these three methods. Not only that, all defragmentation processes can occur with the help of these three methods. Delivering defragmentation is implemented according to the students' needs. Even so, there is the most common method used, namely scaffolding. General scaffolding is given because this method is assistance from experts or other tools that can support students solve problems until they can solve them independently (Chairani, 2015; Kurniasih, 2012). This means that the assistance provided can be reduced gradually so that students can solve mathematical problems without any further assistance.

## CONCLUSION

Students often encounter obstacles in solving problems due to skipping the re-checking stage for the completeness of the finished steps. This is triggered by the habit of students not re-checking the completion steps and making sure the answers are correct. A common type of error in the construction of mathematical concepts is construction holes. The schema appearance can complement the incomplete structure of students' thinking when solving mathematical problems. The most commonly used defragmentation type is scaffolding. The most generally utilized defragmentation type is scaffolding. Scaffolding is considered effective for all types of errors because it can solve and reduce them so that students can finally solve math problems independently.

There are still opportunities to pursue systematic studies related to this research. Depending on the level of education as well as the nature of the thinking error structure, different topics can be studied. Various experiments can also be done to further understand the defragmentation of thinking structures, both generally and in detail.

## REFERENCES

Abidin, Z. (2014). Proses Metakognisi Mahasiswa Calon Guru dalam Memecahkan Masalah Matematika. *Jurnal Riset Pendidikan Matematika*, *2*(1), 25–40.

Biber, Ç., Tuna, A., & Korkmaz, S. (2013). The Mistakes and the misconceptions of the eighth grade students on the subject of angles. *European Journal of Science and Mathematics Education*, *1*(2), 50–59.

Chairani, Z. (2015). Scaffolding dalam pembelajaran matematika. *Math Didactic: Jurnal Pendidikan Matematika*, *1*(1), 39–44. https://doi.org/10.33654/math.v1i1.93

Dwan, K., Gamble, C., Williamson, P. R., & Kirkham, J. J. (2013). Systematic Review of the Empirical Evidence of Study Publication Bias and Outcome Reporting Bias - An Updated Review. *PLoS ONE*, *8*(7), e66844. https://doi.org/10.1371/journal.pone.0066844

Efendi, J. F., & Pratama, R. A. (2020). Defragmenting Proses Berpikir Pseudo Siswa dalam Menyelesaikan Masalah matematika. *AKSIOMA: Jurnal Program Studi Pendidikan Matematika*, *9*(3), 651–661.

https://doi.org/https://doi.org/10.24127/ajpm.v9i3.2956

Gal, H., & Linchevski, L. (2010). To see or not to see: Analyzing difficulties in geometry from the perspective of visual perception. *Educational Studies in Mathematics*, *74*(2), 163–183. https://doi.org/10.1007/s10649-010-9232-y

Gunawati, E., Nusantara, T., & Qohar, A. (2015). Defragmenting Struktur Berpikir Melalui Pemetaan Kognitif Untuk Memperbaiki Kesalahan Siswa dalam menyelesaikan Soal Cerita pada Materi Balok. *Sendimat III: Seminar Nasional Pendidikan Matematika Ke-3*, 257–265.

Hanifah, A. I. (2018). Defragmenting Perajutan Skema Siswa Smp Dalam Menyelesaikan Masalah Aljabar. *Jurnal Reforma*, *7*(1), 12–18. https://doi.org/10.30736/rfma.v7i1.36

Hidayanto, T., Subanji, & Hidayanto, E. (2017). Deskripsi Kesalahan Struktur Berpikir Siswa SMP Dalam Menyelesaikan Masalah Geometri Serta Defragmentingnya: Suatu Studi Kasus. *Jurnal Kajian Pembelajaran Matematika*, *1*(1), 72–81.

Kirnasari, T. P. (2016). *Defragmenting Struktur Berpikir Melalui Pemetaan Kognitif untuk Memperbaiki Kesalahan siswa dalam Memecahkan Masalah Persamaan Kuadrat*. Universitas Negeri Malang.

Kumalasari, F., Nusantara, T., & Sa’dijah, C. (2016). Defragmenting struktur berpikir siswa dalam menyelesaikan masalah pertidaksamaan eksponen. *Jurnal Pendidikan: Teori, Penelitian, Dan Pengembangan*, *1*(2), 246–255.

Kurniasih, A. W. (2012). Scaffolding sebagai Alternatif Upaya Meningkatkan Kemampuan Berpikir Kritis Matematika. *Kreano, Jurnal Matematika Kreatif-Inovatif*, *3*(2), 113–124. https://doi.org/10.15294/kreano.v3i2.2871

National Council Of Teachers Of Mathematics. (2000). Principles and Standards for School Mathematics. *School Science and Mathematics*.

Nazihah, Z. (2018). Defragmening Struktur Berpikir Mahasiswa dalam Mengidentifikasi Homomorfisma Ring. *Jurnal Ilmiah Edukasi & Sosial*, *9*(1), 90–95.

Ribaupierre, A. De. (2015). Piaget’s Theory of Cognitive Development. In *International Encyclopedia of the Social & Behavioral Sciences: Second Edition* (pp. 120–124). https://doi.org/10.1016/B978-0-08-097086-8.23093-6

Rochayati, M. Y., & Fa’ani, A. M. (2019). Defragmentasi Struktur Berpikir Siswa dalam Menyelesaikan Masalah Analogi. *International Conference on Islamic Education: Challenges in Technology and Literacy*, *4*, 321–330.

Septian, A. D., Chandra, T. D., & Dwiyana. (2018). Defragmentasi Struktur Berpikir Siswa Impulsif dalam Menyelesaikan Soal Cerita. *Jurnal Pendidikan*, *3*(8), 994–1011.

Sholekah, L. M., Anggreini, D., & Waluyo, A. (2017). Analisis Kesulitan Siswa Dalam Menyelesaikan Soal Matematika Ditinjau Dari Koneksi Matematis Materi Limit Fungsi. *WACANA AKADEMIKA: Majalah Ilmiah Kependidikan*, *1*(2), 151–163. https://doi.org/10.30738/wa.v1i2.1413

Siregar, N. (2017). Problem Solving Ability Of Students Mathematics In Problem Based Learning. *Journal of Educational Science and Technology (EST)*, *3*, 185. https://doi.org/10.26858/est.v3i3.4475

Subanji. (2015). Pengantar teori kesalahan konstruksi. In *Teori kesalahan konstruksi konsep dan pemecahan masalah matematika* (pp. 1–17). Universitas Negeri Malang.

Subanji, & Nusantara, T. (2013). Karakterisasi kesalahan berpikir siswa dalam mengonstruksi konsep matematika. *Jurnal Ilmu Pendidikan*, *19*(2), 208–217.

Sudbery, J., & Whittaker, A. (2018). Piaget’s theory of cognitive development. In *Human Growth and Development* (pp. 297–300). https://doi.org/10.4324/9780203730386-15

Triutami, T. W., Purwanto, & Abadyo. (2016). Peningkatan Level Kemampuan Siswa SMP Kategori Prestructural dalam Menyelesaikan Soal Geometri melalui Pemberian Scaffolding. *Jurnal Pembelajaran Matematika*, *3*(2), 180–191.

Usodo, B., Aulia, I. I., Wulandari, A. N., Sutopo, Setiawan, R., Kurniawati, I., & Kuswardi, Y. (2020). Fragmentation of thinking structure and its impact to students’ algebraic concept construction and problem solving. *Journal of Physics: Conference Series*, *1567*(3), 1567 032006. https://doi.org/10.1088/1742-6596/1567/3/032006

Wibawa, K. A., Nusantara, T., Subanji, & Parta, I. N. (2018a). Defragmentation of student's thinking structures in solving mathematical problems based on CRA framework. *IOP Conference Series: Journal of Physics*, 012150.

Wibawa, K. A., Nusantara, T., Subanji, S., & Parta, I. N. (2017). Fragmentation of Thinking Structure's Students to Solving the Problem of Application Definite Integral in Area. *International Education Studies*. https://doi.org/10.5539/ies.v10n5p48

Wibawa, K. A., Nusantara, T., Subanji, S., & Parta, I. N. (2018b). Defragmentasi Pengaktifan Skema Mahasiswa Untuk Memperbaiki Terjadinya Berpikir Pseudo Dalam Memecahkan Masalah Matematis. *Prima: Jurnal Pendidikan Matematika*, *2*(2), 93–106. https://doi.org/10.31000/prima.v2i2.755

Wibawa, K. A., Subanji, & Chandra, T. D. (2013). Defragmenting Berpikir Pseudo Siswa Dalam Memecahkan Masalah Limit. *Seminar Nasional Exchange of Experiences Teacher Quality Improvement Program (TEQIP) 2013*, *2*, 721–740.

Wijaya, T. T., Zhou, Y., Ware, A., & Hermita, N. (2021). Improving the Creative Thinking Skills of the Next Generation of Mathematics Teachers Using Dynamic Mathematics Software. *International Journal of Emerging Technologies in Learning*, *16*(13). https://doi.org/10.3991/ijet.v16i13.21535

Wulandari, A. N., Usodo, B., Sutopo, Setiawan, R., Kurniawati, I., Kuswardi, Y., & Aulia, I. I. (2020). Fragmentation of thinking structure: Concept construction and problem solving in geometry of junior high school students. *Journal of Physics: Conference Series*, *1567*(3), 1567 032007. https://doi.org/10.1088/1742-6596/1567/3/032007